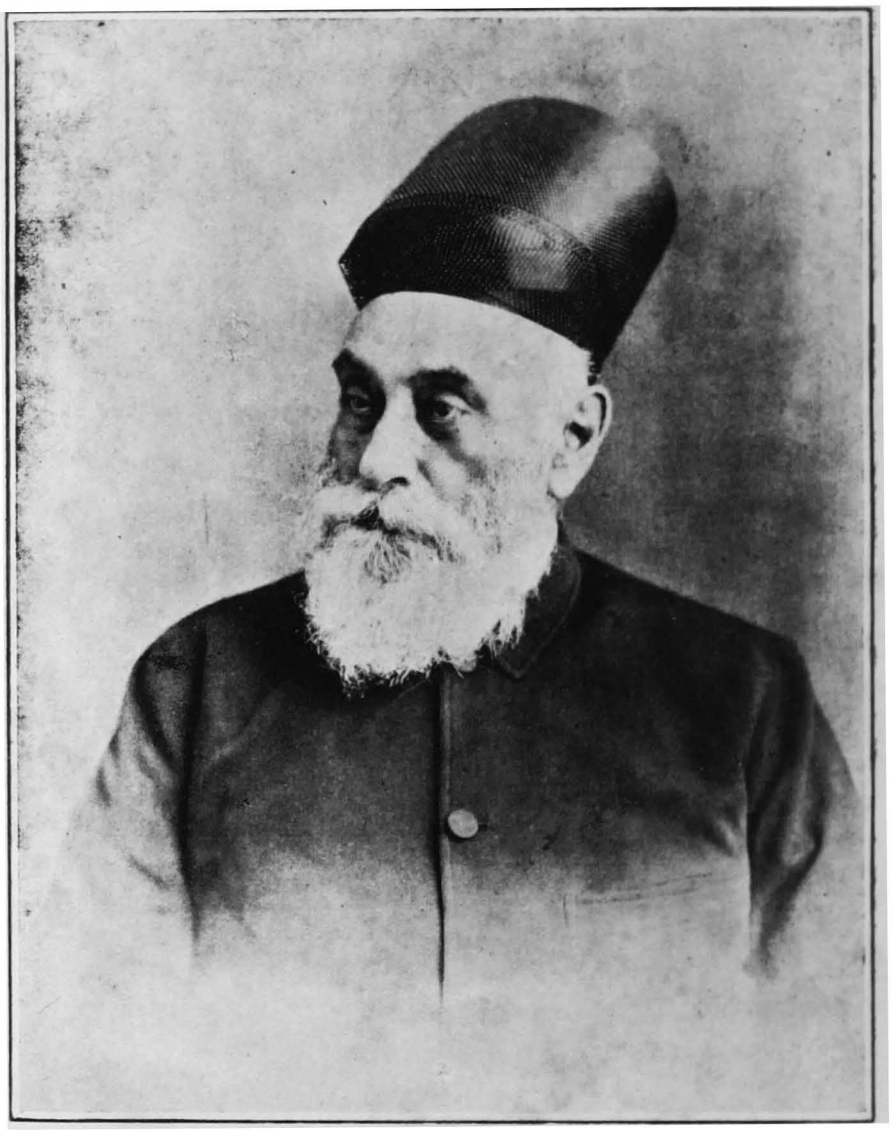

THE LATE MR. JAMSETJI N. TATA. *(Vernon)*

In some respects Mr. Tata was unquestionably the most remarkable Indian of his period. He was a Parsi and his interests centred in Bombay, but his spirit rose above the restraints of race and creed. He belonged to the whole country and did more for its regeneration than any other Indian of modern times.—*The Times* (London)

ELECTRICITY IN INDIA

BEING A HISTORY OF THE

TATA HYDRO-ELECTRIC PROJECT

WITH NOTES ON THE

MILL INDUSTRY IN BOMBAY

AND THE PROGRESS OF

ELECTRIC DRIVE IN INDIAN FACTORIES

EDITED BY S. M. RUTNAGUR,
(*Joint Editor*: "*Indian Textile Journal.*")

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N.B.—Certain sections of the book being printed before January, 1912, the following alterations should be noted.—

For Sir Sassoon David, Kt., read The Hon'ble Sir Sassoon David, Baronet, and for Mr. Shapurji B. Broacha, read Sir Shapurji B. Broacha, Kt

On page 51 "Electrical equipment of mills," last line but three, read £100,000 instead of £75,000; and the total £670,000.

On page 52, line 18 from top read 'voltage 2000' instead of 'voltage 6000.'

PREFACE.

"Electricity in India," deals principally with the Tata hydro-electric project and with the progress in electric power transmission, since Messrs. Crompton & Co. put up the first hydro-electric installation, for the Darjeeling Municipality, in 1896.

The chapter on the history of the Tata project is reproduced with modifications from articles contributed by the author to the columns of the *Indian Textile Journal*. This has been supplemented by an account of the inaugural ceremony at Lonavla and of the progress of the works, tenders etc., to end of April, 1912. The information concerning the mill industry in Bombay and the relative cost of steam and electricity should form a fitting addition to the record of a scheme that will have far-reaching influence on the economy of mill management. The description of electrical power installations in Lancashire mills and the opinions of experts on the improvement in quality and production of yarn and fabrics, will be of interest to Indian mill-owners whose ideas of reform are often drawn from British manufacturers.

The information in connection with the Tata Hydro-electric works, the list of electrical installations in Bombay, Calcutta, Madras and other places and the Directory of electrical engineers are published for the first time, and the author hopes the book may prove useful to manufacturers, capitalists and others interested in electrical work in India.

S. M. RUTNAGUR.

BOMBAY,
May 30th, 1912.

Electricity in India.

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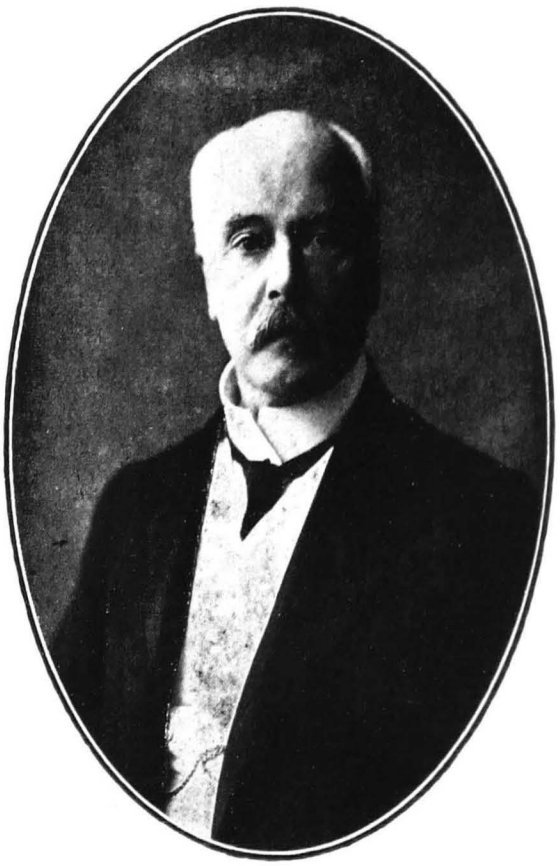


H. E. SIR GEORGE SYDENHAM CLARKE, G.C.M.G., G.C.S.I., G.C.I.E.
GOVERNOR OF BOMBAY.

His Excellency's incessant attention to the social and educational wants of the people has often interfered with his inherent interest in scientific and technical questions. Sir George Clarke came amongst us with a brilliant record of engineering work and when he returns he will leave the city far better equipped for its Industrial requirements than he found it.—*Indian Textile Journal.*

INTRODUCTION.

The inaugural ceremony of the Tata Hydro-electric works which was performed by His Excellency Sir George Clarke, on February 8th, 1911, marked a new era in the history of cotton spinning in Bombay. The commercial activity of the city and its prosperity have been materially dependent on the prosperity of the cotton industry. Of the 6,350,000 spindles installed in the country, nearly 2,900,000 are working in the town and Island of Bombay with 42,500 looms out of a total of 85,300. Until 1886, the city possessed 50 cotton mills with 1,400,000 spindles, but the advent of the ring frame at this period gave an unprecedented impetus to the building of additional factories. News of Mr. Tata's early experiments with the machine and its introduction at the Empress Mills at Nagpur aroused the interest of local spinners. Trial frames were ordered and gave satisfaction, the mill hands taking readily to the new machine for its remarkable simplicity and higher productive qualities. The old fly throstle and mule were discarded; new mills were projected in rapid succession, and over 500,000 spindles were added between 1886 and 1890 in Bombay Island alone. This innovation was followed by the introduction of the flat card, which in time completely superseded the revolving card, and these and higher counts, fancy weaving, dyeing, bleaching and finishing, helped towards progress and prosperity, till the growing competition in the East and the varying conditions of labour and raw material, called for economies in manufacture which could no longer be overlooked.

The feasibility of the transport of electrical energy to long distances, and its utility in the driving of spinning and weaving machinery, have been long since recognised, especially in districts where the current can be produced by water-power. With the introduction of electrical energy from the Tata Hydro-electric Works at Lonavla, the cotton mills of Bombay will have been furnished with all that is modern in power transmission and benefit by the economy in manufacture that has been a conspicuons feature of the electric drive. Even the British manufacturers, with coal near at hand, seem to realise its advantages. In 1905, there was scarcely a complete electrically driven cotton mill in Lancashire; there are now over 50,000 horse power in motors working in the textile factories alone, of which approximately 30,000 are driven by current supplied from outside sources. A description of the more important installations in Lancashire is published on page 61, and it will be seen that the current in the majority of cases is purchased from Central Power Stations where the energy is being generated, almost exclusively, by steam power; this, among other reasons, has restricted the

use of electricity for power purposes in Lancashire factories. If Great Britain had possessed the natural advantages of water-power, electricity would in all probability have played a more important part in the economy of production in her manufactories than has hitherto been possible with steam. For it must be noted that nearly 80 per cent. of the power required for the American and Canadian mills is obtained hydro-electrically and approximately 50 per cent. of European mills outside of the United Kingdom are similarly driven.

India, with a more costly fuel supply, has not been backward in taking advantage of the subtle fluid for power purposes. In 1907, when the electrification of Bombay factories under Messrs. Tata's license seemed assured by Sir Sassoon's guarantee, enquiries were instituted into the probable advantages of electric power transmission; and while London financiers were discussing the Tata project, India was importing electrical machinery on a scale unprecedented in her trade history. Dynamos and motors were introduced in workshops and factories of every description; experimental plants in cotton mills were installed with results that proved satisfactory, except, of course, in cases where the equipment was inferior or where experienced supervision was not available.

The Director of Commerce and Industries, in his Report on the Trade of India, referred to this increase, pointing out that the value of steam engines imported into the country declined from £918,200 in 1908, to £723,900 in 1909, while the import of electrical machinery, valued at £236,500 in 1909, shewed substantial progress, and that a good deal of this electrical plant belonged to the textile industry. The latter statement is borne out by the number of installations in cotton and jute factories now aggregating approximately 10,000 H. P., the bulk of which has been put up in factories in the Bombay Presidency.

Progress in other directions has been equally noteworthy. The People's Bank at Lahore, has secured a license from the Government of the Punjab for the supply of electric energy for light and power in the city and civil station, the capital being estimated at Rs. 7½ lacs. Messrs. Killick, Nixon & Co., of Bombay, have obtained a concession for electric light and power supply within the limits of Ahmedabad city, while a Joint Stock Company has been formed by Messrs. Crompton & Company, Limited, Bombay, for an undertaking to supply electrical energy for traction and power purposes in the city of Nagpur. Almost every railway in the country has now been equipped with generating sets and motors; the lighting of cities with electricity and electric traction have been largely extended; collieries, iron works, mines, oil mills, flour mills and other factories have been fitted with electrical appliances the extent of which can only be roughly estimated by the limited information contained in these pages.

The World's Water-Power.

The extent to which water power has been utilised for industrial purposes and the various uses to which electricity produced by water power can be economically applied have been made apparent by the success of the works at Niagara and other industrial centres in America and on the Continent.

According to Mr. Otto Mayr, a German authority, Norway uses 300,000 horse-power and Sweden 200,000; Italy uses 464,000 horse-power, France, 1,190,000, Austria 450,000, Germany 503,300, Switzerland 380,000, and Hungary 65,000 horse-power. The total available water-power for the whole Continent is estimated at 34,151,600 horse-power, of which only 3,594,100 is utilised. These are, however, only approximate figures, as in the case of Italy and Switzerland, the data are brought down to the end of 1905 only, and in the case of France and Germany they are for the year 1907. With regard to Italy, at the end of 1906 the water power used totalled 830,000 horse-power; of this 740,000 was transformed into electrical energy and 90,000 applied directly.

One of the latest hydro-electric works has been started at Necaxa by the Mexican Light and Power Company. The problem was to install hydro-electric plants on the Necaxa and Tenango Rivers and to transmit the power to the city of Mexico, situated on a plateau whose altitude is between 7,000 and 8,000 feet above sea level. An enormous dam, 180 feet in height and more than 1,200 feet long, was built at the point where the Necaxa river breaks through the mountain range bordering the plateau, the natural shape of the valley being such that a large volume of water could be impounded. Other dams in the tributaries of the river form gigantic storage reservoirs which hold sufficient water to run the generators for months during the dry season. The power house is situated at the foot of an enormous cliff 800 feet high and contains six impulse water-wheels operating under a head of 1,300 feet, each wheel being connected to a 5,000 K.W., three-phase 50-cycle, 4,000 volt generator of the revolving-field type.

Hydro-Electric Power in Japan.

By a strange coincidence the extent of the latest hydro-electric undertaking in Japan compares very closely with the Bombay project. Both the schemes in their extended form can supply 50,000 to 60,000 horse-power at approximately the same outlay. The Japanese project will comprise the largest waterpower plant so far undertaken in that country. There will be three generating stations in the province of Shiznoka, the city of Tokyo, which is about a hundred miles to the west, taking up the bulk of the power. Six three-phase 25 cycle generators will be coupled direct to water wheels of 13,500 horse-power capacity. The length of the transmission line will be about 105 miles, distributing the current in Tokyo, Yokohama and adjacent cities.

Water Power in India.

India possesses sufficient water power in various districts which is being gradually utilised for industrial purposes. The first hydro-electric installation of which we have information, was carried out in 1896 for the Darjeeling Municipality by Messrs. Crompton & Company, Ld., Chelmsford. Previous to this, in 1875, Mr. J. N. Tata seems to have realised the advantages of water power and applied for a concession for utilising the water falls near the Marble Rocks at Jubalpore. The concession was not allowed but his early investigations stimulated further enquiries which were continued by Mr. David Gostling and others in districts within easier reach of industrial centres.

If Bombay is favourably situated as a centre of industrial activity, she is equally fortunate in the possession of those economical sources of power supply, which have contributed to the success of electrical undertakings in other countries. In an editorial in the *Indian Textile Journal* for September, 1899, Mr. John Wallace, C.E., indicated the prospects of water power from the ghauts near Bombay as under :

"The progress made in the economy of transport of electric current brings us each year nearer the time when the power of falling water in the Ghauts on the other side of Bombay harbour will be utilised in our city for industrial purposes. The rainfall of the hill-tops during the five months monsoon varies from 200 to as much as 400 inches, and the highest summit in our district is 4,700 feet above the level of the sea. It would be necessary in order to utilise the rainfall for industrial purposes to make storage reservoirs in upland valleys to provide a water supply during the seven dry months of the year, and the conformation of the valleys would have to be such that the cost of the dam or bund should not be excessive. . . .

"The impounding of water in the upper valleys of the Ghauts may be regarded from the double point of view of motive power and agriculture. During the rains more power runs to waste in the thousands of waterfalls among the Ghauts than would supply every factory in the Presidency with power the year through. It would light our cities, propel our tramcars, pump our sewage, load and unload our ships, propel hundreds of electric motor cars, pull all our punkhas and do a large proportion of domestic labour. Electricity has hitherto led a rather precarious existence in Bombay for reasons which our limit of space forbids us to enter into, but we venture to think that, with the enormous resources of force that are wasted within sight of our city, the electrical engineer may look forward to a period of intense activity and of prosperity."

This period has happily commenced with the construction of the Tata hydro-electric works at Lonavla which are to supply electrical energy for the industries of Bombay.

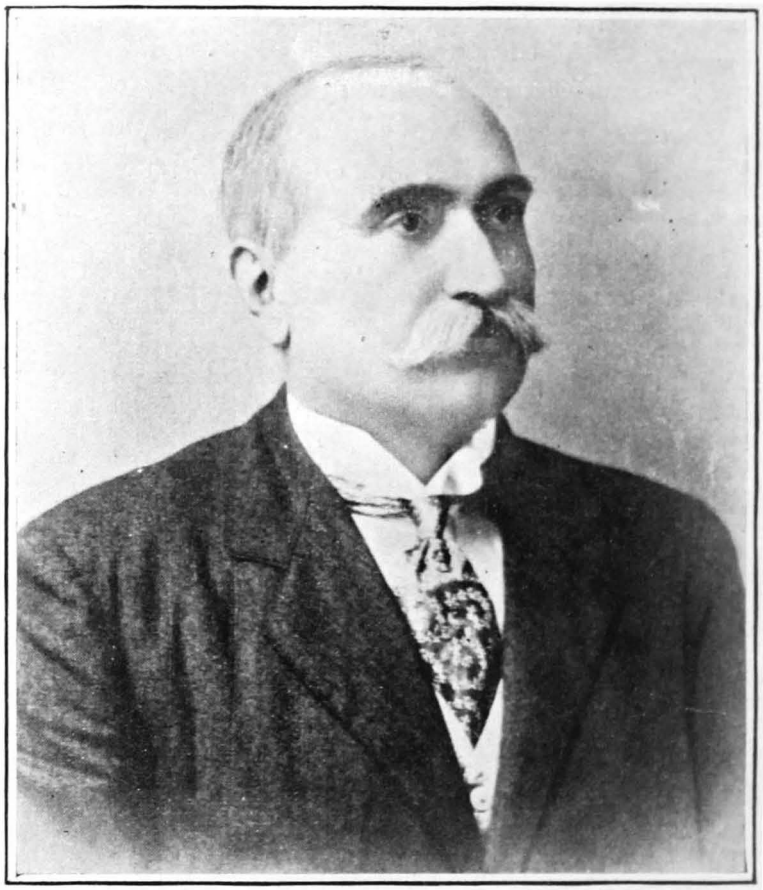
The project was conceived by Mr. David Gostling in 1895 and took many years to mature. Minor installations were put up in the interval, the most notable being the plant of the General Electric Company at the famous Cauvery Falls, near Mysore. Started in 1902, it has been worked with conspicuous success under the supervision of Mr. H. P. Gibbs, M.I.E.E. The present works have a capacity for 13,000 horse-power at an outlay of Rs. 75 lacs, the energy being conveyed through transformers to a distance of 35 miles to the city of Mysore, and 60 miles to the city of Bangalore, for light and power purposes; a third line takes it to the Kolar Goldfields, 92 miles distant, which take the bulk of the power. An extension has now been taken in hand and when completed the whole plant will be capable of yielding a total of 20,000 horse-power.

The State of Patiala has a hydro-electric installation for city lighting, power supply, and water works. The current is conveyed 18 miles from the generating station, the plant for which has been supplied by Messrs. Siemens Brothers. The engineering works at Basantpur, in connection with the Simla hydro-electric installation, furnished by the same makers, are making good progress. The long flume from Mautikhud to the bank of the Sutlej river is approaching completion. A large reservoir is being constructed, in which water of the Mautikhud will be collected, and therefrom it will be carried in pipes to the bank of the Sutlej, where there will be a head of 550 feet which will supply power to generate electricity for Simla and to pump up its water supply.

The Hydro-electric Station at Srinagar, Kashmir, contains four double water-wheel units with automatic pressure governors, each unit capable of delivering 1765 B. H. P. to the shaft under an effective head of 400 feet, with four alternators each rated at 1000 K. W. This plant is manufactured by the General Electric Company of New York, the hydraulic apparatus being supplied by Messrs. Abner Doble & Company of San Francisco. The power house has cost Rs. 50 lacs, including the generating, transmission and distributing plants.

The electric current is finding favour even in far-off Afghanistan. H. M. the Amir has arranged with Messrs. F. & C. Osler, Ld., of Calcutta, for a scheme for electric lighting and power supply in his dominions. The cost of the undertaking is estimated at Rs. 10,00,000, the machinery for the generating plant being supplied by the General Electric Company, Messrs. Osler Ld. furnishing all other electrical apparatus, pumps, motors and the entire lighting plant.

Among minor installations, are the Hydro-electric Station at Mussoorie, and the Water Power Station of the Cordite Works at Wellington on the Nilghiris, the Hydro-electric Works at Munnar and at Gokak, South India, the State Plant at Nepal, and other schemes that have been suggested, including the Periyar project for Madras and the Mourbhanj scheme for Calcutta.



SIR DORABJI JAMSETJI TATA, KT.

Sir Dorabji Tata, the senior representative of a family whose name must ever be imperishably associated with that industrial rejuvenation of India, destined, in all probability, to inaugurate an entirely new era in civilization, is a worthy son of a worthy father. The Tatas, members of the virile race which has given a new impetus to commerce in Western India, are to Hindustan what the Mitsuis are to Japan, the Rothschilds to Europe, the Vanderbilts and the Astors to America.—*Mayfair* (London.)

The Tata Hydro-electric Project.

The Tata project is by far the largest hydro-electric undertaking that has been projected in India and in respect of the enormous quantity of water that will be impounded by the dams, it will constitute the largest of its kind in the world. The scheme as originally laid out covered three separate vallyes enclosed by masonry dams designed to hold in the aggregate sufficient water to deliver approximately 60,000 horse-power in Bombay, which would be sufficient for all practical requirements of the local industries. The present works have however been laid out for only 30,000 horse-power delivered in Bombay at an estimated outlay of Rs. 175 lacs. Power will be obtained from two reservoirs—the Lonavla and the Wahlwan, having a storage capacity of 380 million and 2,800 million cubic feet respectively. The water will be led by a masonry duct to the forebay 2,040 feet above sea-level, whence it will enter steel pipes leading to the Turbo-generators at the power house below, the head being 1,730 feet and the static pressure 680 pounds to the square inch. The generating plant will be erected 300 feet above sea level, and will consist of four main sets of hydraulic turbines coupled direct to three-phase generators, each giving 8,000 kilowatts at normal full load. The current will be raised by transformers to 100,000 volts and brought to Bombay through overhead transmission lines, a distance of 43 miles.

After years of waiting the Tata Hydro-electric project has now been successfully launched; its history is the history of long periods of careful study and investigation; of strenuous effort and heavy outlay indicating the vast resources and enterprize of the family that has contributed so liberally towards India's industrial regeneration. Of the early band of workers Mr. Tata died in 1904 and Mr. Gostling in 1908; Mr. Millar had retired from the country, and the responsibilities of the work lay principally on the shoulders of Sir Dorabji Tata, assisted by Messrs. B. J. Padshaw and A. J. Bilimoria. The scheme reached its critical stage during the latter part of 1910; the opportunities that were offered had to be carefully considered and followed up, even at the risk of failure. For years Sir Dorabji had devoted himself to the completion of the great work his father had undertaken; he rose to the occasion, and had the satisfaction of putting the scheme through with the prospect of success fully assured.

Scarcely a project of any industrial importance in the country has been started under the same favourable conditions; every rupee of the large capital was subscribed for before a stone was laid at Lonavla; and of the power that will be available, the whole has been taken up in advance and the revenue of the shareholders secured for ten years; the construction of the huge dams is proceeding satisfactorily and the progress on the whole has fulfilled the best expectations of engineers and contractors,—the rest is in the lap of the gods.

THE LATE MR. DAVID GOSTLING, F.R.S.A.

MR. R. B. JOYNER, C.I.E., M.I.C.E.

DR. JOHN MANNHEIM.

Mr. Joyner and Dr. Mannheim were sent out to India by Messrs. Dickinson on behalf of the Syndicate to verify and develop Mr. Gostling's original proposals in connection with the hydraulic part of the project and to investigate into the general prospects of the scheme. The very careful surveys and enquiries conducted by these engineers resulted in the formation of the project that has been taken over by the Tata Hydro-electric Power Supply Company Limited.

History of the Project.

The late Mr. David Gostling, one of the best known architects of this city, conceived the idea of utilising the heavy rainfall on the Ghauts for industrial purposes in Bombay. There was one citizen who could appreciate the suggestion and carry it through, and that was Jamsetji Tata. With characterestic thoroughness he made a minute study of Mr. Gostling's initial proposals, developing them eventually into an extended project, which was to place our factories on a higher level of economy.

Of all the schemes—and there were many—which Mr. Jamsetji Tata conceived or adopted, the electrification of the local factories was as precious to his heart as the manufacture of iron and steel, and when death suddenly removed this great pioneer of industries on May 19th, 1904, the work of completion devolved on his sons.

The Bombay Hydro-Electric Syndicate.

The project was, however, too large to be handled without substantial financial aid and expert advice, the capital being roughly estimated at over a million and a half sterling if the full requirements of the local mill industry were to be met. A syndicate consisting of Messrs. Tata and other financiers was formed in 1905 and registered in London as the Bombay Hydro-electric Syndicate, Limited. Messrs. David Gostling, Robert Miller, James Brown and Edward Miller, joined the Syndicate, which appointed Messrs. Alfred Dickinson and Co., of London and Birmingham, its Consulting Engineers and general advisers. The next step was to verify and develop Mr. Gostling's original propositions in connection with the hydraulic works, and to enquire into the general prospects of the scheme. Accordingly Messrs. Dickinson sent out in 1905, Dr. John Mannheim, an electrical expert, to make careful enquiries into the engineering and commercial aspect of the undertaking, while Mr. R. B. Joyner, C.I.E., M.I.C.E., was engaged to make special investigations in connection with the hydraulic part of the project. Mr. Joyner had rendered valuable services for nearly 30 years, in the engineering department of the Government of Bombay. His unique experience of water-works and large engineering projects including the Gokak Falls, and his intimate knowledge of the districts near Lonavla, proved of great value to the promoters, and it should be gratifying to Government that a retired member of the Public Works service has been associated in this important undertaking.

The very careful suveys and investigations carried on by these engineers resulted in the formation of the scheme which has been taken over by the Tata Hydro-electric Power Supply Company Limited.

Early Difficulties: Hon. Sir Sassoon's Co-operation.

It was however early in 1906 that the investigations were completed ; the project from an engineering point of view possessed all the elements of success, and financiers were ready to support it. Scarcely, however, a mill in India had then been electrified. Would the output of power under Messrs. Tata's License find a market, or would the scheme have to withstand the prejudice of Bombay mill-owners and suffer by conflicting interests and opposition ? During this anxious period Messrs. Tata found a colleague whose co-operation proved of great value. The Hon. Sir Sassoon David, Bart., realised in 1906 the possible development of electrical energy for power transmission and its beneficial influence on the mill industry, and supported the venture by guaranteeing a substantial proportion of the available energy. This proved a wise precaution on the part of the early promotors ; because in 1910, when the Company was registered and applications for power supply were invited, Bombay mill-owners as a body made but a feeble response, while the railways, the Port Trust and other large consumers were not prepared for electrification. The available horse power was, however, taken up almost wholly by the guarantors and their friends which secured a most satisfactory start for the Company.

Application for License.

Sir Sassoon's guarantee gave considerable impetus to the progress of the scheme and a License to carry through the undertaking was applied for by Sir Dorabji and Mr. Ratanji Jamsetji Tata on behalf of the Syndicate. A concession for the supply of electricity to the public had already been granted to the Bombay Electric Supply and Tramway Company, Limited, which opposed Messrs. Tata's application. The rights of the pioneer company and the services rendered by it in the electrification of the tramway had to be considered, and while not admitting the monopoly of the first concession, Government offered to make a fair and equitable arrangement for the distribution of the limited supply which the Hydro-electric Company proposed to furnish.

Views of the Bombay Government.

After a somewhat lengthy enquiry in the course of which Dr. Mannheim rendered valuable assistance, it was decided to grant the License to Messrs. Tata, and a Resolution was accordingly issued on Novenber 15th, 1906, to the effect that,—

"Government find the scheme put forward by the Bombay Hydro-electric Company sound, inasmuch as it will bring to Bombay a supply of electric power approximately equivalent to 40,000 H. P., at a price lower than the cost of coal-generated engine-power, and also cheaper than electrical power can be generated in Bombay itself with coal.

"Natural advantages at the Ghauts at Lonavla enable Government to develop this power for general benefit, as electric power is in every way

THE HON. SIR SASSOON DAVID, BARONET.

Indian commerce has equal reason to be grateful to H. E. Sir George Clarke, whose unfailing interest has supported the undertaking through every crisis, and to the Hon. Sir Sassoon David, Baronet, but for whose timely Guarantee much of the necessary capital would have had to be raised in London.—*The Pioneer.*

a marked advance on ordinary steam power for driving mills, factories &c., being more cleanly and sanitary, and also, Government are advised, of distinct advantage to manufacturers, as yarn and cloth produced in mills driven by electric power are found to be of better quality than the same produced in mills driven by steam. Moreover, the introduction of electric power will abate the smoke nuisance and reduce the consumption of water.

"Bombay could well do with 100,000 H. P. for power purposes, but unfortunately the extent of water power is limited, and the Bombay Hydro-electric Company will only be able to supply about 40,000 H. P. Government consider they should encourage its introduction to Bombay and therefore have resolved to grant a License; and in doing this they have taken into consideration the fact that with the present advance of scientific appliances for all commercial purposes they would be neglecting an obvious duty if they failed to harness this power which lies at their hands at the Ghauts."

Opinion of Leading Officials, Millowners and Merchants.

Before however, the License was granted, a public enquiry was held in the Town Hall, under the orders of Government, by Mr. G. W. Hatch, I.C.S., Collector of Bombay. The Hon'ble Sir Henry Procter, then Chairman of the Chamber of Commerce, and the Hon'ble Sir Vithaldas Thakersey, representing the Millowners' Association, were present, and they stated that cheap electric power, such as the Tata Company offered to provide, would be of benefiit to the industries of Bombay; and that as the prosperity of Bombay was bound up with the prosperity of its industries—and particularly of its cotton mill—a scheme that benefited the mills or other industries must be held to be of benefit to the city at large. The Hon'ble Sir Henry Procter was further of opinion that it would abate the smoke nuisance, and the Hon. Sir Vithaldas referred to this nuisance, and to the saving of Municipal water as distinct advantages to the general public.

Mr. Courtenay Wright, Deputy Chairman of the Chamber of Commerce, and the Hon. Mr. C. H. Armstrong also attended the meeting at the invitation of Government and stated that the scheme would be of advantage to the Bombay public generally, both from an industrial and sanitary point of view.

In concluding his Report in connection with the enquiry Mr. Hatch remarked: "I may mention here, for the information of Government, that the opinion of representative men in Bombay is, so far as I can judge, unanimous on the point that the introduction of cheap electric power into the Bombay mills is likely to prove useful to the public. Sir Walter Hughes and Mr. W. D. Sheppard, I.C.S., were prepared to state their opinions to this effect, and I do not believe a single opinion to the contrary could be obtained in Bombay."

The Crisis in the American Money Market.

The License was ultimately granted on March 7th, 1907, and in October Sir Shapurji Broacha Kt., joined the Hon. Sir Sassoon in the Guarantee for power. Messrs. Tata and the Syndicate pushed on with their financial negotiations and in this they were considerably helped by the guarantee, as it practically insured the whole of the expenditure on the output of nearly 30,000 H. P. By the end of 1907 they had almost secured the necessary capital and it then appeared that the Company would be registered at the beginning of 1908. The crisis, however, which followed soon after in the American money market seriously affected the situation, and for some time the scheme kept swinging between the varying offers of British and Indian financiers.

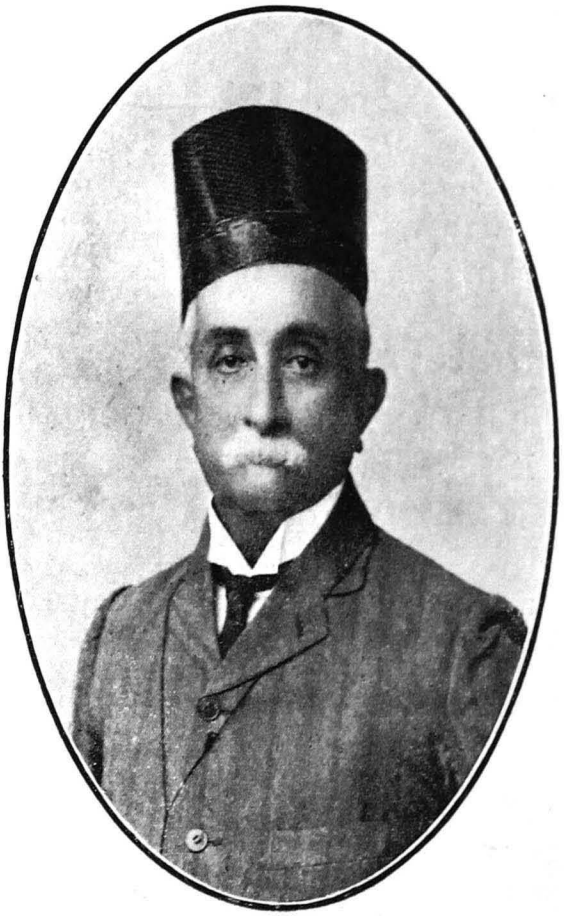
The Turning Point: Official Encouragement.

On the other hand, electric driving was making steady progress in textile factories. Even the Lancashire manufacturers, with coal near at hand, began to realise its advantages and while the prospects of the Hydro-electric undertaking were being discussed by financiers, electrical power installations were being fitted in cotton mills and jute factories, the railways and other workshops throughout India. Meantime Messrs. Tata persevered with the project in a depressed market, often hampered by conditions which they would not accept in fairness to the colleagues who were associated with them in this important undertaking. Offers and counter-offers were made, fresh surveys were held and favourably reported on, till ultimately, about the middle of June, 1910, a definite proposal was received from London financiers to carry it through. But a still better prospect was in store.

H. E. Sir George Clarke.

H. E. Sir George Clarke, Governor of Bombay, who had taken a keen interest in the progress of the scheme, suggested that the profits of such an important undertaking should if possible remain in the country. Himself an engineer, His Excellency could appreciate the potentialities of a project of this magnitude, and on July 2nd, 1910, at the opening ceremony of a new cotton mill at Sholapur, he observed :

"While Indian capital has now happily been attracted to your mill industry, I have been much struck with the difficulty in obtaining it for other enterprises. There is an excellent hydro-electric project for Bombay, which still awaits initiation. Experience has shown the great value of cheap electricity in connection with a growing city. The conditions in Bombay are exceptionally favourable, and it was my great hope that the scheme could be launched entirely upon Indian capital. I am informed, however, that this has been found impracticable and it now seems inevitable that a great part of the money



SIR SHAPURJI B. BROACHA, KT.

At a later stage Sir Shapurji joined the Hon. Sir Sassoon David, Baronet, as a guarantor of power and rendered valuable assistance to Messrs. Tata in the financing of the scheme by influencing the whole of the Debenture Stock, amounting to Rs. 55 lacs (or £3,66,600) equal to one-third the required capital.

required will have to be raised in England. There are obvious advantages in carrying out such a scheme as a purely Indian undertaking, and I regret that I see no hopes that this can be arranged."

These remarks, and His Excellency's general advice and suggestions as Governor and engineer, increased the confidence of investors, and the project was put through by Sir Dorabji Tata and his colleagues with the liberal co-operation of local financiers and the Rulers of leading Native States in the Presidency.

Share Capital, Revenue and Profits.

The Company was registered on November 7th, 1910, with a nominal capital of Rs. 2,00,00,000 divided into 10,000 ordinary and 10,000 preference shares of Rs. 1,000 each. Perference shareholders are entitled to a fixed cumulative dividend of 7 per cent. and the Ordinary and Perference Shares will carry 4 per cent. interest during the construction period.

The Capital of Rs. 175 lacs required for the present scheme has been fully subscribed and distributed in—Rs. 55 lacs Debentures at 5½ per cent.; Rs. 60 lacs Preference Shares at 7 per cent. and Rs. 60 lacs Ordinary Shares.

The present scheme will deliver in Bombay about 30,000 H. P., the annual revenue being estimated at Rs. 27·844 lacs and the gross expenditure at Rs. 11·475, leaving Rs. 16·369 lacs profit to be utilized as under,—Interest on Debentures Rs. 3·05 lacs or 5½ per cent.; on Preference Shares Rs. 4·2 lacs or 7 per cent., and on Ordinary Shares, Rs. 9·144 lacs or 15 per cent.

If the scheme is eventually extended the aggregate capital required will be Rs. 250 lacs as under,—Debentures Rs. 80 lacs at 5½ per cent., Preference Shares Rs. 85 lacs at 7 per cent., and Ordinary Shares Rs. 85 lacs.

The enlarged Works will deliver about 50,000 H. P. in Bombay estimated to yield an annual revenue of Rs. 51.0 lacs. The gross expenditure in this case is expected to average only Rs. 15.0 lacs per year, leaving a profit of Rs. 36 lacs for dividend viz.: Rs. 4.4 lacs or 5½ per cent. on Debentures, Rs. 6.0 lacs or 7 per cent. on Preference Shares and Rs. 25.6 lacs or 30 per cent. on Ordinary Shares.

The Management.

Messrs. Tata Sons and Company have been appointed Managing Agents on a remuneration of five per cent. on the net profits of the Company and actual office expenses.

The Board of Directors consists of Sir D. J. Tata, Kt., *Chairman*; The Hon. Sir Sassoon David, Kt., Mr. R. D. Tata, Mr. S. B. Broacha, The Hon. Mr. Lalubhai Samaldas, Mr. P. D. Pattani, C.I.E., Dewan of Bhavnagar, Mr. V. Y. Vanikar, Accountant-General, Baroda State, Mr. H. J. Bhabha, Retd. Inspector-General of Education, Mysore State, Mr. W. H. White, C.S.I., Bombay, P.W.D., Retd., the Hon. Sir Vithaldas Damodher Thackersey, Kt., and Mr. Narottam Morarjee Goculdas.

The Bombay Hydro-electric License.

The License extends to the limits of Bombay city, excluding however, all naval and military quarters, and the energy has to be generated by water power only.

In view of the concession already granted to the Tramway Company, Government have embodied certain modifications in the original terms of Messrs. Tata's application, the principal being that the Tata Company cannot supply any consumer requiring less than 500,000 units per year, equivalent to say 250 I. H. P. per hour ; the Tramway Company, on the other hand, cannot buy current from the Hydro-electric Company and resell to a mill or factory that consumes more than 300 I. H. P. per hour.

The present supply being limited to about 30,000 H. P., the Hydro-electric Company has to advertise its terms of supply and invite applications from the public, including cotton mills and other factories, the railways, and even the Tramway Company, should the latter prefer to buy its current rather than produce it as hitherto. Applications will be registered and accepted in the order of receipt.

Contracts with Cotton Mills.

A clause in the License which will interest millowners is the provision that special flat rate contracts may be entered into with cotton mills and other factories requiring at least 300,000 units per quarter year, or an equivalent of about 600 I. H. P. per hour, at a rate not exceeding ·75 anna per unit. The Licensees are not bound to take any contract on these terms which is for less than five years ; they have also the option to prefer a longer period contract to a shorter period contract and may require proof or security that the applicant is in a position to carry out his contract.

The Tramway Company's Position.

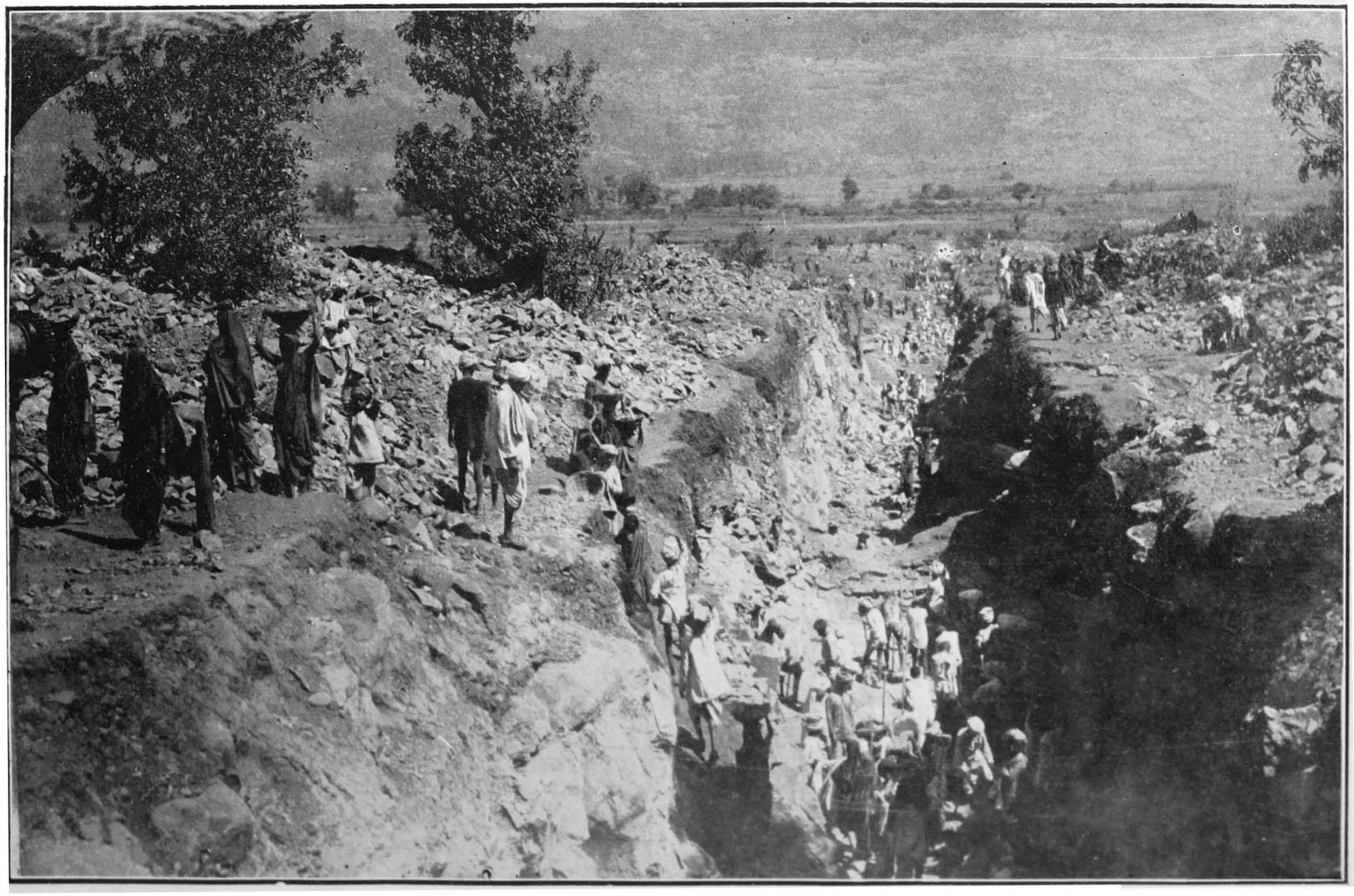
The probability of the Bombay Electric Supply and Tramway Company coming to an understanding with the Tata Company has not been overlooked, for it has been provided that the Tata Company may sell its current to the Tramway Company at a lower rate than is paid by the cotton mills, provided the Tramway Company buys the energy for purposes of resale to the extent of at least 300,000 units per quarter year, or say 600 I. H. P. per hour. For the local tramways and for private lighting in residences and offices, the Tramway Company has practically the monopoly, but cotton mills which buy current for driving their machinery from the Hydro-electric supply, will also be allowed to use energy for lighting through separate meters not exceeding in any year, 20 per cent. of the total energy used by the mill for power purposes. The maximum charge for lighting is fixed at two annas per unit.

MR. R. D. TATA.

MR. RATAN TATA.

MR. A. J. EILIMORIA.

Mr. R. D. Tata was the head of the firm of Tata & Co., until its affiliation in 1908 with Tata Sons & Co. He was the first to export Indian cotton to Japan on a commercial scale and to establish for the purpose his own offices in that country. He also formed fresh connections by opening branches for Messrs. Tata, in New York and Paris. Mr. Ratan Tata is the second son of Mr. Jamsetji Tata, and is well known for his commercial enterprise, and his liberal contributions towards educational and philanthropic work. Mr. Bilimoria had been the life-long lieutenant of Mr. Jamsetji Tata. Joining early in 1884, he took an active part in the development of Mr. Tata's extensive operations and co operated in the success of the undertakings initiated by him. On the reconstitution of the firm in 1908, Mr. Bilimoria was taken partner—a fitting appreciation of long and meritorious services.



THE TATA HYDRO-ELECTRIC WORKS: THE SITE FOR THE LONAVLA DAM.

The Hydraulic Works at Lonavla.

Lonavla, the well-known hill station on the summit of the Bhor Ghats, is the site for the reservoirs, which will store water during the rainfall estimated to average 175 inches, thus ensuring a continuous supply for the Generating Plant 2,000 feet below. The Lakes will be formed by constructing masonry dams across two valleys, the Lonavla and the Walwhan; the third, known as the Shiratwa valley, being reserved for future extension.

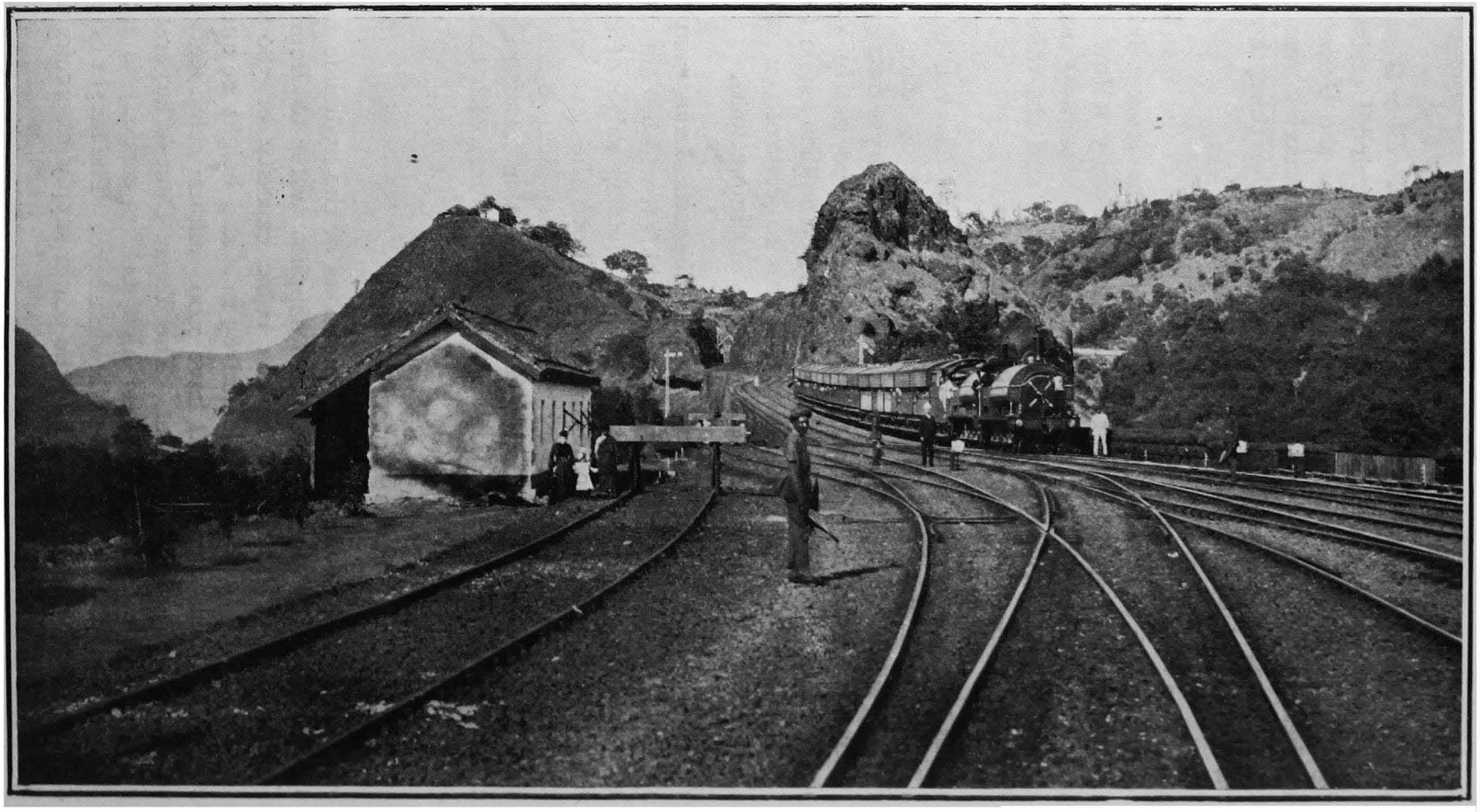
The Lonavla lake will supply power during three months of the monsoon, and it will be large enough to hold sufficient water during the longest breaks in the rains. Its area will approximate 1,000 acres formed by a low dam 3,800 feet long and holding up 26 feet depth of water with a roadway over it and two waste escapes, one leading to the Bay of Bengal and the other to the Indian Ocean. Its capacity will be 380 million cubic feet.

The Walwhan lake will be a storage reservoir to serve for the rest of the year. It will be situated near the Walwhan village about 1½ miles from Lonavla station, and will be formed between two spurs of hills by a dam 4,500 feet long, and about 68 feet high. The area of the lake will be nearly 1,540 acres, or about 2½ square miles, and its capacity 2,800 million cubic feet. The dam will be of solid masonry fitted with sluices to control the water supply to the Duct leading to the Forebay at the edge of the precipice.

Later on, a third lake, to be known as the Shiratwa Lake, may be constructed in a valley beyond Walwhan lake, with which it will be connected by a tunnel nearly a mile long, running through the dividing ridge of steep hills, which will form the watershed some 1,200 feet above the level of the valley. This lake will also be held up by a large masonry dam, 8,000 feet long, its greatest height above the foundation being 93 feet, thus forming a very capacious reservoir for nearly 7,000 million cubic feet of water, with an area of 3,174 acres or nearly 5 square miles.

The Tansa Water Works.

It will be interesting to compare the dimensions of the hydraulic lakes at Lonavla with those of the Tansa Lake which supplies water to Bombay. The Lonavla and Walwhan lakes will have a cubic capacity of 380 and 2,800 million feet; length of dams ·72 mile and ·85 mile and height 26 and 68 feet respectively. The Shirwata lake will have 7,000 million cubic feet, the length of dam 1·5 mile and its height 93 feet. The Tansa Dam is larger still, being 8,800 feet or 1·6 miles long and 118 feet high, but its capacity is 2,574 million cubic feet, or less than that of the Walwhan lake. The height of the Tansa lake is 400 feet above sea level, while the power supply reservoirs will be over 2,000 feet above sea level.



Bourne and Shepherd,

THE REVERSING STATION AT KHANDALLA.

The water from the reservoirs will be led by means of pipes through a tunnel built underneath the Railway Lines shewn in the photograph. The Power Station will be erected in the valley below to the left of the picture.

The Course of the Water.

The water from the Walwhan Lake will be led to the edge of the Ghauts near Khandalla, through a masonry Duct, running first across a level plain, then crossing rough ground, across ravines and deep water-courses, over the Bombay-Poona Road and the G. I. P. Railway, through stone aqueducts and tunnels to the Forebay, traversing an aggregate distance of nearly four miles. Arrangements will be made to lead the water from the Lonavla lake to the Duct during the monsoon. The Forebay will be situated 2,040 feet above sea-level, and the water from it will enter pipes six feet in diameter which will run a distance of nearly 12,500 feet, down the steep slopes and precipices, dividing out in their descent and passing through a tunnel under the Reversing Station (shown in the illustration) and down the cliff into the valley below, to Khopoli, where the Power House will be built. The head will be a little over 1,730 feet, or ten times as great as that of Niagara, the static pressure being 680 pounds per square inch.

The Power House.

The Power House will be erected near the Railway Terminus at Khopoli, on a spot nearly 300 feet above sea-level, which will allow of the tail-water being utilised for industrial and other purposes. It will be fitted with Turbo-generators and electrical plant of the most modern type that have been in successful operation in large hydro-electric power stations on the Continent and the United States, and will include four main sets of Hydraulic Turbines of the Pelton or Impulse type. Each Turbine will be coupled direct to Generators (three-phase) giving 8000 Kilowatts at normal full load. There will also be two auxiliary sets of Hydro-turbines direct-coupled to Generators of 850 H. P. capacity to supply direct current for the excitation of the main three phase Sets and to furnish power to the Station motors, lighting and accumulator circuits. The main Turbines will probably be designed to run at 300 R. P. M. and the Excitor sets at 600 R. P. M.

The Receiving Station in Bombay.

The energy generated will be raised by Transformers to 100,000 volts at which pressure the current will be conducted to Bombay by high tension transmission wires supported on a line of steel towers. The length covered by the wires, from Generating to Receiving Station will be 43 miles, while the railway distance from Khopoli to Bombay extends to 70 miles.

The Receiving Station will be located near Sewree with the distributing and sub-stations in close proximity to the cotton mills and railway workshops, the current being supplied at a pressure of from 200 to 3,000 volts.

The Engineering and Supervision of the Works.

The general designing and engineering of the project has been placed in good hands. Mr. Alfred Dickinson, M.I.C.E., M.I.E.E., M.I.M.E., has been retained as Consulting Engineer to the Company. From its initial stage Mr. Dickinson has taken an active part in the development of the hydro-electric scheme. His experience of electrical power plants has been considerable, nearly 30,000 H. P. having been installed in different places under his supervision, while the cost of the civil engineering work done by him will aggregate several millions sterling; he is is now engaged on a deep sea wharf which will take the

MR. H. P. GIBBS, M.I.E E., ETC.

MR. ALFRED DICKINSON, M I.C.E., ETC.

largest vessels afloat. As a pupil of the late Mr. Charles Sacré, Mr. Dickinson has had exceptional opportunities for studying his profession. For nearly ten years from 1884 he was chief engineer and general manager of the largest mechanically worked tramway system in Europe and commenced an independent practice from 1893. Since then his advice has been sought for large and varied engineering projects in all parts of the world from Cuba in the West to Tokio in the East, and he has carried out important works in Great Britain, Ireland, Spain, France, South Africa, China, Straits Settlements, and other countries in connection with civil, mechanical and electrical undertakings. His accumulated experience of many years should prove of great value in the completion of the Tata Hydro-electric Works.

Mr. H. P. Gibbs, M.I.E.E., New York, M.I.E.E., London, has been appointed General Manager of the Company, and a more capable officer could not have been selected for the post. Brought up in a country that has given the world some of its best talents in electrical science and engineering

Mr. Gibbs has been able to obtain wide and varied experience of electrical undertakings of all kinds. As consulting expert his advice has often been sought to rectify errors and derangements in the erection and working of complicated machinery and plants which other engineers were unable to set right. This experience necessarily developed his resources to act in emergencies and qualified Mr. Gibbs for more important responsibilities. In 1899 he went to Mexico and installed a large mining plant complete in every respect, and two years later he came out to India as Chief Engineer for the Kolar Gold Mines Electrical Installation, at Mysore. Early in 1903 he was placed in entire charge of the Cauvery Power Scheme with the success of which his name has been intimately associated, and subsequently as Chief Electrical Engineer to the Government of Mysore, he designed and carried out several schemes including an electrical winding plant, one of the most important the world has seen. The choice of an expert for large undertakings in India has often been a matter of difficulty, as the special conditions of climate and labour have to be reckoned along with technical and trade peculiarities. Mr. Gibbs combines the highest qualifications of an electrical engineer with the practical knowledge and experience of Indian requirements which should contribute materially to the successful working of this important undertaking.

Contracts and Tenders for the Works.

The contract for the hydraulic part of the Works, estimated at Rs. 40½ lacs (*£270,000*), has been placed with Messrs. Pauling & Company, of London, and is in charge of Mr. Oswald Ormsby, M.I.C.E The cables for the underground mains in Bombay will be supplied and laid by Messrs. Callenders Cable and Construction Co., Ld., under the supervision of Mr. W. Roberts. This work is estimated to cost Rs. 7½ lacs (£50,000), exclusive of the charges for maintenance, which has also been entrusted to the same firm. Messrs. Callenders are also contractors for the Bombay Electric Supply and Tramways Company, whose extensive cable system for traction and lighting has been satisfactorily carried out and is now being maintained by them.

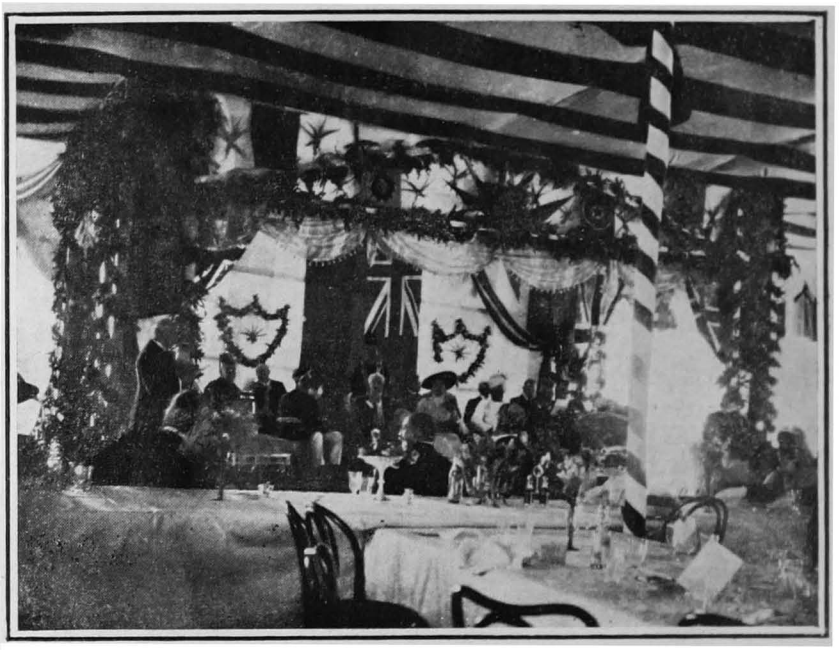
Specifications and Tenders for the Pipe Lines, the Generating Plant Transformers and for the supply, erection and maintenance of the motors, meters, switches and wiring for the electrical driving of the cotton mills are now under consideration, the following among other firms having sent in their tenders :—Messrs. The British Westinghouse Electric and Manufacturing Co., the General Electric Company (New York), Siemens Bros. Dynamo Works, Limited, the A. E. G. Lahmeyer Company of Frankfurt-on-Main, the Brush Electrical Engineering Company, the Lancashire Dynamo and Motor Company, and Mather and Platt Limited. The aggregate amount of these Tenders is estimated at Rs. 30 lacs or *£200,000*.

Metzkar, Poona.

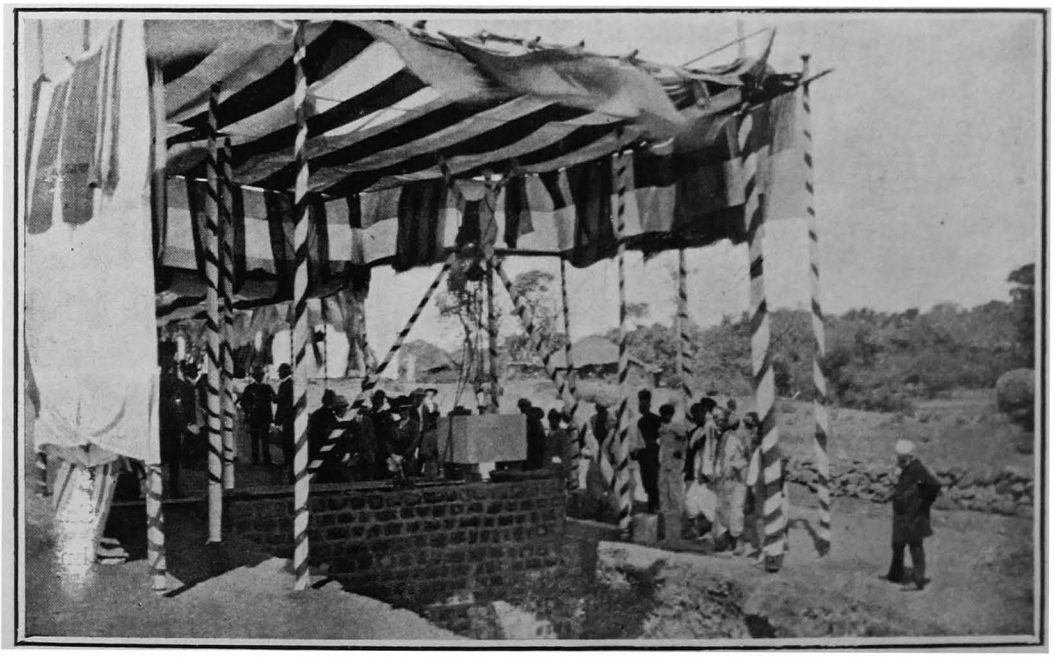
A Group of Guests at the Inaugural Ceremony at Lonavla.

The Inaugural Ceremony.

Although unaccompanied by any official circumstance, the ceremony of inaugurating the Tata Hydro-Electric Power Supply Company, Limited, at Lonavla on February 8th, 1911, assumed the importance of a great Bombay function. His Excellency the Governor, Sir George Clarke, laid the foundation stone of the Lonavla Dam, Her Excellency Lady Clarke graced the proceedings with her presence, and there were gathered on the top of the Ghauts representative men from all parts of the Presidency and from other provinces of India. Messrs. Tata Sons & Co., as Agents for the Company, invited leading citizens of all shades of opinion and representative of all classes and communities to be present, and between three and four hundred accepted these invitations. They included the members of his Excellency's Council, the Hon. Mr. Chaubal, the Hon. Mr. Morison, and the Hon. Mr. Lamb. Many other high officers of Government were present, including the Hon. Mr. Carmichael, Chief Secretary, and the Hon. Mr. Cameron, P. W. D. Secretary. Nearly all the leading Bombay bankers attended, many merchants of standing, a large number of professional men, and a goodly attendance of ladies. Indeed, it was commonly remarked that the commercial world of Bombay must be at a standstill to allow so many leading men to take holiday. For their accommodation and entertainment admirable arrangements were made. Two Special Trains ran from Bombay to Lonavla, one leaving at nine thirty and the second, in which His Excellency travelled, at ten-fifteen. These Special Trains were made up of the finest rolling stock of the G. I. P. Railway, and each was accompanied by a restaurant car, where light refreshments were served. Each guest received in advance a card indicating by which train he should travel, so that there was no confusion and no crowding. The journey to Lonavla was made in two and a half hours, and, arrived there, motor cars were in readiness to convey the guests to the huge Shamiana, pitched close to the site of the dam. This Shamiana was brightly and prettily decorated, and the air of Lonavla was cool and refreshing after the journey. A dainty lunch was served by the Taj Mahal Hotel, the proceedings being enlivened by the playing of the fine hotel band. The lunch over, their Excellencies took their seats on a raised dais, where they were joined amongst others by His Highness the Maharajah of Mysore, and His Highness the Thakore Saheb of Limbdi. His Highness the Gaekwar sent a telegram of regret, and His Highness the Maharajah of Bhavnagar was represented by his Dewan, Mr. Prabhashanker Pattani, C.I.E. In a voice that was heard throughout the large Shamiana Sir Dorab Tata then explained the origin and growth of the scheme.—(*Times of India.*)



SIR DORAB TATA ADDRESSING THE ASSEMBLY.



THE FOUNDATION STONE BEFORE THE CEREMONY.

Speech by Sir Dorab Tata.

Sir Dorab said:—As the Chairman of the Tata Hydro-Electric Power Supply Company, Ld., and speaking on behalf of the shareholders, I have the honour to request Your Excellency to lay this foundation-stone, and thereby to inaugurate the works of the Company. At the same time it is most gratifying to me to be able to stand before you as the representative of my father, who, if he was not the first to recognise the adaptability of these regions to the production of electrical energy through the agency of the waterpower available on the Western Ghats, had prominently before his mind for nearly thirty years before his death, the fact that cheap power could be obtained from the hydraulic resources of this country, and to realize that the utilisation of these resources would give a great stimulus to industry. As far back as 1875, in the course of his travels throughout India, when he was looking for a suitable site for cotton mills in the Central Provinces, he realized that the water-falls near the Jubbulpore Marble Rocks might provide cheap power, and tried unsuccessfully to secure a concession which would have permitted further investigation. About the same time he endeavoured with equal want of success to obtain concessions from the Central Provinces Government for the establishment of iron works in the Chanda District.

Mr. Jamsetji Tata's Aims.

To my father the acquisition of wealth was only a secondary object in life; it was always subordinate to the constant desire in his heart to improve the industrial and intellectual condition of the people of this country; and the various enterprises which he from time to time undertook in his lifetime had for their principal object the advancement of India in these important respects. To me it is a matter of the utmost regret that he is not alive to-day to see the accomplishment of the three cherished aims of the last years of his life, viz:—(1) The Research Institute, (2) The Iron and Steel Project, and (3) The Hydro-Electric Scheme. Kind fate has, however, permitted me to help in bringing to completion his inestimable legacy of service to the country, and it is a matter of the greatest gratification to his sons to have been permitted to carry to fruition the sacred trust which he committed to their charge.

The conception of the idea, which formed the foundation of this scheme, which Your Excellency will to-day inaugurate, was due to that well-known citizen of Bombay, the late Mr. David Gostling, a Civil Engineer of repute, who did not confine his energies to his profession, but devoted them with zeal to the service of the city in many directions. About the end of 1897, Mr. Miller, a member of the firm of Messrs. C. MacDonald and Co., Manchester and Bombay, was offered the option of purchasing rights connected with the Doodh-Sagar Falls near Goa. Realizing that before anything could be done, the falls and the surrounding ground wonld have to be surveyed with a view to their being used for a water-power scheme, he employed the late Mr Gostling to make the survey in December of that year. Mr. Gostling brought away rather a good opinion of the potentialities of the falls and held out hopes that they might be useful for commercial purposes

Mr. Miller thereupon obtained a firm offer for the property, and early in 1898 approached my father to seek his co-operation. Mr. Tata, with his usual clear-headedness, saw that there were valuable possibilities in the scheme, and at once agreed to form a syndicate in conjunction with Mr. Miller and Mr. Gostling. With the further history of this syndicate, we have nothing to do at present, beyond stating that it is still in existence, and there is reason to hope that it may form the basis of another water-power scheme at no very distant date.

The Original Idea.

In June 1899, shortly after the formation of this Syndicate, Mr. Gostling informed his partners that he had a much larger and better scheme nearer home, on which he had been working for some five years, during which period he had been in the habit of passing all his spare time at Lonavla, personally taking levels and noting contours. He had conceived the idea that, though there was no continuous water fall, the physical formation of these regions was such that it was possible to construct lakes and store enormous quantities of water in the higher valleys at Lonavla, which, being conveyed by gravity to the edge of the plateau at Khandala, and then allowed to precipitate itself through pipe lines down the steep hill-side to the foot of the Ghauts at Khopoli, would create a fall giving a 'head' of water of 1,734 feet, which, I believe, is one of the largest in the world. By means of turbines, this fall would generate electrical energy, which could be conveyed to a receiving station in Bombay by over-head transmission lines, whence it could be distributed to consumers in various parts of the Island.

This, in short, was the idea, which ultimately germinated into the full-fledged scheme which Your Excellency is now about to inaugurate. The proposition was very favourably considered by Mr. Tata, who for years had contemplated a water-power scheme; so the idea of generating electric power by means of water appealed to him at once both as an industrial and commercial enterprise. It was then arranged that the same three interests concerned in the Doodh-Sagar Scheme should form a separate Syndicate to develop this project. Mr. Gostling continued to work at his facts and figures, the necessary expenses being thenceforward borne by the Syndicate, for which Mr. Miller continued to do useful work in England, in dealing with Mr. Gostling's plans and data and carrying on correspondence with Engineers and others. Meantime, Mr. Tata took charge of the commercial side of the project. Happening to be in England in the summer of 1900, he had the honour of an interview with Lord George Hamilton, the then Secretary of State for India, on the subject of the Research Institute. During this interview he had an accidental opportunity of laying before Lord George Hamilton the outlines of the Hydro-electric and the Iron Works projects which were both received so favourably as to encourage him to proceed further with these enterprises. On his return to India, Mr. Tata, in accordance with instructions, put himself in communication with Mr. Ritchie, Private Secretary to the Secretary of State for India, to report progress.

Lord George Hamilton's Approval.

One of the objects of this correspondence was to obtain the goodwill of the Secretary of State in support of the application to the Government of Bombay to put the Land Acquisition Act in force for the acquisition of the necessary lands for the lakes and works, to obtain the necessary grants of Government waste and forest lands, and to secure the recognition of the Syndicate as the originators of the project. Mr. Ritchie replied on behalf of the Secretary of State in very encouraging terms, and he confidentially transmitted the correspondence to Lord Northcote, Governor of Bombay. I here take the liberty of quoting the following paragraph from Mr. Ritchie's letter of 21st June, 1901, to my father in this connection: "As to the second scheme for utilizing the electric power generated in the heights of the Ghauts for the purposes of Bombay and its neighbourhood, Lord George can only say that if it is brought to a successful issue, it will be an achievement of which you may indeed be proud." As a result of this communication from Mr. Ritchie, my father and Mr. Gostling were able to interview His Excellency Lord Northcote in Poona, when they laid before him the scheme in all its details. About this time, Mr. Bingham arrived in Bombay, as a representative of the Pioneer Electric Light and Power Co., for the purpose of entering into an agreement with the Bombay Municipality to supply electric power to Bombay. Our Syndicate, which I joined at this stage, entered into futile and lengthy negotiations with him with a view to combination, but these did not result in business. In order to safeguard the possibilities of a large electric scheme at a later date, Mr. Tata had further interviews with Lord Northcote, at which he laboured to establish the principle that the Government and the Municipality should not grant any monopoly for the sale of electric energy to the Pioneer or any other Company that might be formed. Up to this time, the scheme, as conceived by Mr. Gostling, was of limited scope. But the occurrence of a cycle of deficient monsoons gave rise to anxiety, and it was thought that the project as it then stood did not provide sufficient water storage. Mr. Gostling set about exploring the neighbourhood and surveyed the valley of Walvahan, east of Lonavla, a plan of which he prepared by the middle of 1905. This valley has a watershed of 5½ square miles and the lake, when dammed, will have an area of 2½ square miles.

The Capital Difficulty.

At the time of my father's death in May 1904, the scheme had so far advanced that he had interested Government in it and enlisted their sympathy. After my father's death, the scheme underwent various vicissitudes. Anxious as we were to start the enterprise in India with Indian capital, at one time it was found almost impossible to do so. Consequently, it became necessary to enlist financial interests in England, where another Syndicate was formed in the summer of 1905 to take over the work of flotation from our Syndicate, but in joint partnership. But before that, Messrs. Alfred Dickinson and Co., Consulting Engineers of London and Birmingham, had been appointed to assist and advise generally on the whole scheme. We regard ourselves as particularly fortunate in securing the services of so experienced an engineer as Mr. Alfred Dickinson, because since he commenced practice as a consulting engineer in 1893 he has advised on large and varied engineering schemes in many parts of the world and works costing many

millions sterling; the Board have every confidence in his ability to carry out this great work. This firm's services were taken over by the new Syndicate, who late in 1905 sent to India Dr. John Mannheim, of the firm of Messrs. Alfred Dickinson & Co., who was instructed to make thorough investigation, not only of the engineering, but also of the commercial possibilities of the enterprise. His work, which necessitated several visits to India, was thoroughly done, and enabled his firm to prepare all the necessary electric plans. Dr. Mannheim was accompanied by Mr. R. B. Joyner, C.I.E., M.I.C.E., who had retired from Government service after occupying a high position in the Public Works Department, and had acquired wide experience of irrigation works in Western India. He was retained to thoroughly investigate Mr. Gostling's proposition, to make suggestions and to advise upon the hydraulic work proposed. Both gentlemen applied themselves zealously to this very onerous work, and the result is the scheme as it stands to-day. I may safely say that few schemes have been more fully investigated from an engineering point of view, and the final plans represent continuous work extending over many years, during which the ground has been surveyed several times and the whole project favourably advised on by competent engineers.

Thanks to Officials.

Here I must pause to give due meed of praise and grateful thanks to two gentlemen to whom the Company owes a deep debt of gratitude. I refer to Mr. W. White, C.S.I., and to the Hon'ble Mr. W. L. Cameron, C.S.I. The former of these gentlemen, whom you all know as a distinguished engineer, was Secretary to Government in the P. W. D. at the time when we had to obtain recognition by Government, and their approval of our aims and objects as well as of our methods. He was quick to recognise the engineering possibilities of the enterprise and the far-reaching benefits it would confer upon Bombay. The support and encouragement that we have received in our work from Government are, I may say, largely due to the interest Mr. White took in it from the very beginning and which he has continued to show up to the present moment. After his retirement, the scheme found a no less warm supporter and friend in his successor, the Hon'ble Mr. W. L. Cameron, C.S.I., whose generous criticism, sound advice and the sympathetic interest he evinced in everything connected with this project, enable me to stand where I do now before this distinguished company to witness this inauguration ceremony. I also take this opportunity of publicly acknowledging, with my greatful thanks, the help, advice and personal courtesies I encountered from officials of every class, whether belonging to the Government of India or local District officers, with whom I have come into contact. This side of my duties—and I had much interviewing to do—formed the most pleasant part of my work. Mr. Alfred Dickinson, our consulting engineer, who is responsible for all the details of the Scheme, desires that I should testify, and I do so with the greatest pleasure, to the great engineering skill and ability Mr. R. B. Joyner has brought to bear on the hydraulic section of the work. To Mr. Joyner is due the entire credit for the designs of the dams, ducts and all the work in connection therewith. Mr. Joyner, on arrival, made an independent survey of the two valleys, also of the Khandala Ridge up to Byramji's Bungalow and of the Reversing Station Ghaut down to the Power House at Khopoli. He also surveyed an extension to the east of the

Walvahan Valley, named the Shirvata valley. He found that the watershed of the Walvahan valley was of large area, capable of feeding huge lakes, which could be connected by a tunnel with the Walvahan Lake, and that the addition of the Shirvata Lake would cause no addition to the length of the masonry duct from the Walvahan Lake. While Mr. Joyner was engaged in his surveys, both he and Mr. Gostling located other valleys in that neighbourhood, which will provide an ample supply of water for any future extensions that may be needed to supply Bombay and the immediate neighbourhood at a later date. These valleys thus form an additional insurance against any shortage of power from deficient rainfall.

Combination of Advantages.

But, greatly as we were taken by the engineering posibilities of the scheme, and firmly convinced as we were that the engineers could do all they anticipated, there remained to be decided the important question of cost to consumers. It had first to be proved that whilst paying a reasonable rate of interest upon the capital involved, electric power could be sold to the millowners in Bombay at a less cost than the price of steam power. As the result of numerous tests carried out by our firm at our own mills, and of careful inquiries in many directions, I am glad to be able to state that this has been found possible. The Company is prepared to enter into contracts to supply electric power to mills for the very low rate of .55 of an anna per unit, including the maintenance of all the electrical machinery, which will be installed by our Company at its own cost.

Here it may be useful to enumerate briefly the rare combination of advantages which this scheme offers:—

(*a*) There is a 'head' of 1,734 feet, ten times as great as that at Niagara, and four times as great as that at the Cauvery. This involves a great saving in the height of the dams; and what that means will be understood when it is stated that the cost of the dams in the present scheme is roughly estimated at 19 lakhs, and that with the Cauvery 'head' at the ghauts it would have been put down at many times that sum, as four times as much water would be required to produce the same power. The cost with the Niagara 'head' at the Ghauts would have been absolutely prohibitive.

(*b*) The rainfall is unusually high (an average of 175 inches) or about five times the average at the Cauvery.

(*c*) The natural geology and formation of the valleys are very favourable to water-tight storage with a reasonable dam-wall.

(*d*) Power has to be carried over a transmission line of 43 miles only, at 100,000 voltage pressure; the Cauvery has a length of 92 miles at 35,000 volts. If the transmission line had the length and voltage of the Cauvery, the estimated cost of the transmission lines from the Ghauts would have been increased from 7½ lakhs to over 30 lakhs.

(*e*) The transmission line offers no engineering difficulties.

(*f*) Nowhere else in India is such a ready market for so much power, and a great block of power has been already underwritten. I fear I am wearying you with these details, but I must refer to the fact that, important as is the question of the relative cost of power, it is but small, compared with many other advantages to be derived by the adoption of the electric drive. It enables the millowner to work

independently not only on each floor, but on part of each floor, or, if he so desires, any particular machine, without calling into requisition his big engine for the purpose, so that he can run one part of his mill without regard to any other part. But, again, this is only one of the many advantages of an electric drive. The millowner, by careful readings of the power used, can check the output of each department and the efficiency of the machines in that department. The adoption of the electric drive will enable him to ascertain from his employees in any one department why they used so much power one week and only turned out so much material, when in another week the results were different.

Cotton Mills and Electric Power.

But these two universally recognised facts stand out clearly, viz:—(i) That the output is increased by the use of the electric drive as against the steam drive. (ii) That the quality of the output is better. Amongst other advantages I must also mention the saving in the cost of engine and boiler-room staff. The advantages will be great to the existing steam-mill owners, but far greater to prospective owners of new mills, for they will have, in addition, the advantage of being able to employ in productive machinery all the capital they would have had to spend under ordinary circumstances on buildings, boilers, steam engines, foundations and reservoirs, and all the other incidentals in connection with a steam drive plant.

Ladies and gentlemen, I think I have said enough about the financial advantages. Just a word about what is, after all, of much more importance to us all—health and sanitation. Of course the latter is included in the former, but just for a moment think what a glorious city Bombay would be if freed from smoke. I do not ask any one to rid Bombay of smoke at his own cost; but if he can do it—and save money—by adopting the electric drive, I am sure he will himself want to do it. Being so closely associated with Bombay, I am perhaps too ready to believe it to be one of the most beautiful cities in the Empire. I am sure it will be acknowledged to be such by everybody, if it only can be rid of the smoke nuisance; and I venture to add that it can also be made one of the healthiest.

If you will pardon this brief digression I will now, with your permission, summarise the history of the closing stages of the enterprise. In February, 1906, my brother and I, on behalf of the Syndicate, applied to the Government for a License under the Indian Electricity Act of 1903 for the supply to the public in Bombay, of electrical energy to be generated by water-power at the Ghauts. The license was granted to us in 1907. The great task of promoting a Company with sufficient capital to work the License still remained. It would be useless and not in the least interesting, to describe the various endeavours, both in England and in India, to raise the necessary capital. Suffice it to say that in November 1910, a Company was registered, with the nominal capital of two crores of rupees, divided into 10,000 ordinary shares of Rs. 1,000 each and 10,000 cumulative 7 per cent. preference shares of Rs. 1,000 each. Out of this capital, 60 lakhs of ordinary and 60 lakhs of preference shares have now been issued. In addition a debenture loan of 55 lakhs has also been floated. An interesting feature of this subscription list is that the bulk of these shares and debentures has been taken up by some of the most prominent Ruling Chiefs and Princes of India.

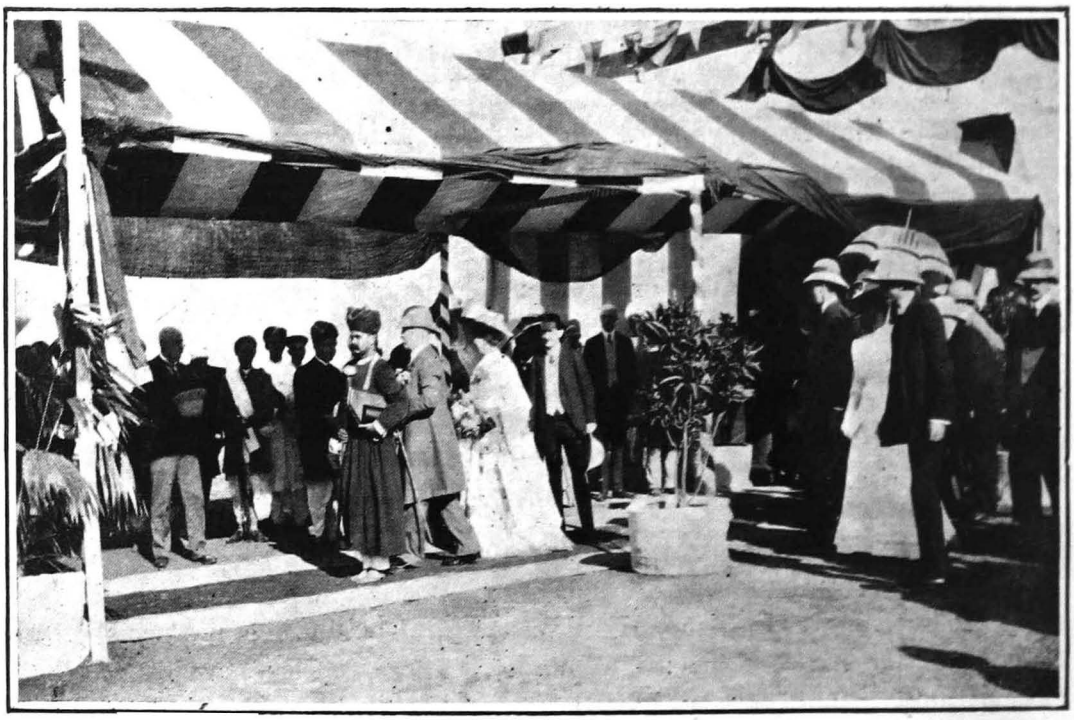
The present scheme is sufficient to supply to Bombay in a season of least rainfall 30,000 E. H. P. estimated on a basis of 3,600 working hours per annum, but every provision has been made for the enlargement of the scheme by the inclusion of the Shirwata Valley, which will bring up the total of E. H. P. to 50,000.

Encouragement from H. E. Sir George Clarke.

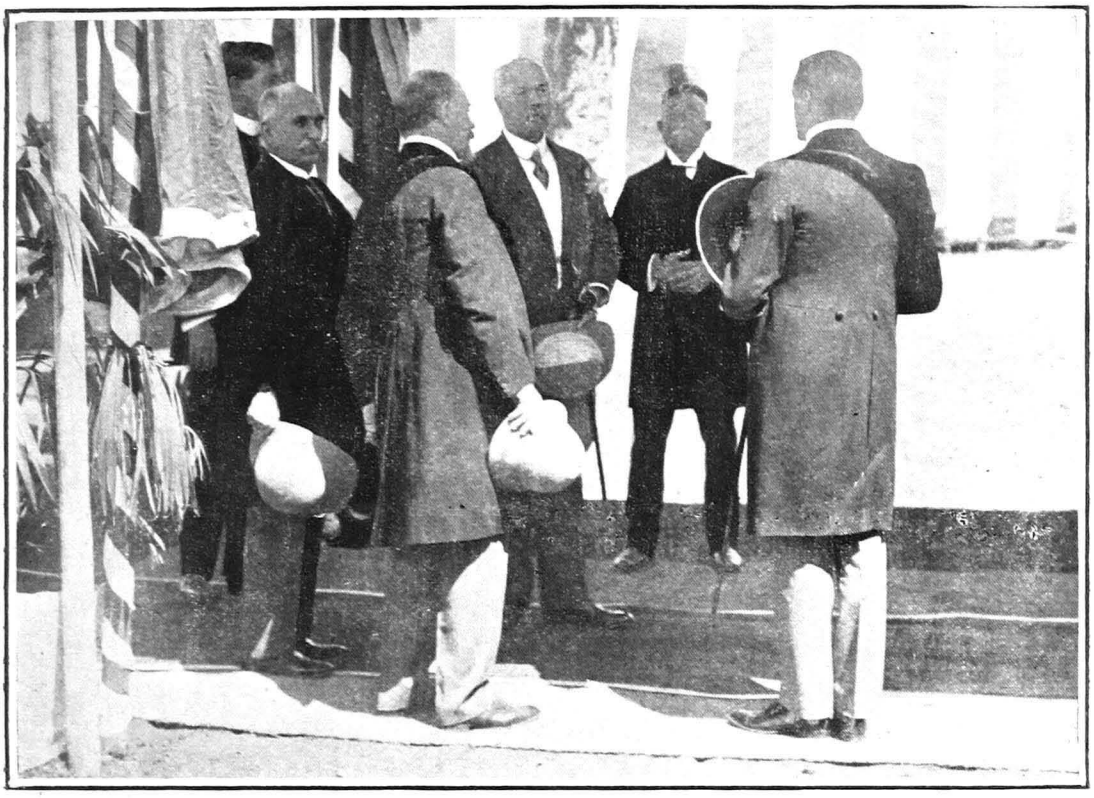
And now, Ladies and Gentlemen, having, I fear, wearied you with this recital of the history of the Ghaut Hydro-electric project, we have reached the stage when actual constructive work will be commenced. As one of the promoters, and as the eldest son of Mr. Jamsetji Tata, I may perhaps be excused a sentiment of pride and gratification in the knowledge that this great enterprise has been financed entirely with Indian money, and in the assurance that further capital, when required, will be forthcoming from the same source. But, if I am able to make this proud boast, if we are able to assemble here to inaugurate a scheme which, I trust, will familiarise Indian capitalists with great enterprise, I will ask you to bear with me, whilst I tell you that this successful issue of our long labours is due to the personal intervention of the head of this Presidency, His Excellency Sir George Clarke. It is impossible for me adequately to express the obligation under which His Excellency has placed the Company, and all associated with this enterprise, by the kindly interest he has taken in the work, and the unfailing encouragement he has extended to us on every possible occasion. For myself, I will tell you frankly that at one time I had virtually lost heart, as I felt that it would be impossible to finance the scheme with Indian money. It was His Excellency who revived hope, helped us forward at every turn, and stimulated interest in others. I owe an inexpressible debt of gratitude to Sir George Clarke for the statesmanlike attitude he has ever manifested towards the project, an attitude dictated by the conviction that the Hydro-Electric scheme is something more than a common joint stock enterprise, and a work that is destined to exercise a fertilising influence on Bombay industries, a curative influence on its smoke-laden atmosphere, and a stimulating influence on major Indian enterprise.

It is no exaggeration to say that the turning point in the fortunes of the Company, as far as the raising of capital was concerned, was reached when, in a speech at Sholapur on July 2nd, His Excellency referred to the prospects of the Company in these wise words:—"While Indian capital has now happily been attracted to your mill industry, I have been much struck with the difficulty in obtaining it for other enterprises. There is an excellent hydro-electric project for Bombay, which still awaits initiation. Experience has shown the great value of cheap electricity in connection with a growing city. The conditions in Bombay are exceptionally favourable, and it was my great hope that the scheme could be launched entirely upon Indian capital. I am informed however, that this has been found impracticable, and it now seems inevitable that a great part of the money required will have to be raised in England. There are obvious advantages in carrying out such a scheme as a purely Indian undertaking, and I regret that I see no hopes that this can be arranged."

That speech struck a patriotic chord in the hearts of the Princes and peoples of India, which produced an immediate response, and from that day the prospects of financing the Company with Indian capital were placed on a firm footing. Our task was still laborious; difficulties had to be met and overcome; but from this point we never looked back, we were filled with hope, and our optimism was justified by the launching of the Company in November 1910. It is only fitting that an enterprise on which Your Excellency has conferred so many benefits should be personally inaugurated by you: it is with a heart charged with gratitude for the inestimable services you have rendered this enterprise, filled with the hope that the future of the Company will prove worthy of the support it has received, and that this auspicious beginning may prove of great augury for the future, that I ask Your Excellency to add to the many obligations under which you have laid the Board by laying the foundation stone; Your Excellency Lady Clarke to accept our sincere thanks for gracing these proceedings with your presence, and Ladies and Gentlemen all for your encouraging attendance here to-day.



HIS EXCELLENCY PROCEEDING TO LAY THE FOUNDATION STONE.



SIR DORABJI. HIS EXCELLENCY. MR. SHAPURJI BROACHA.
MR. DICKINSON. MR. GIBBS.

H. E. Sir George Clarke conversing with the Engineers.

Laying the Foundation Stone.

An adjournment was then made down a covered way to the site of the dam—a huge trench running right across the valley. Here Sir Dorabji Tata introduced Mr. Alfred Dickinson, Consulting Engineer and Mr. Harry Parker Gibbs, General Manager of the Company, to His Excellency. The arrival of Their Excellencies was the signal for the firing of a number of charges which reverberated across the valley, throwing huge masses of earth and stones into the air. Then, having laid the foundation stone well and truly, His Excellency returned to the dais and said :

Speech by His Excellency the Governor.

Sir Dorab Tata, Your Highnesses, ladies and gentlemen,—All who are keenly interested in the life of India and who are studying the economic position of this great country must often rub their eyes in wonder at the statements they read in some Indian newspapers. I have over and over again learned that India is being rapidly ruined, that her industries are perishing, that her wealth, formerly fabulous, has now disappeared, and that while other countries flourish she alone is steadily retrograding. I do not know why such statements are eagerly impressed upon a credulous people; but I do know that they have no basis of fact and I have little doubt that the sense of discouragement they must produce does check our progress. They find an echo in the press and on the platform in other countries, and timid people who have not the smallest knowledge of Indian conditions are thus led to believe that the most foolish thing they can do is to invest in Indian securities. I suggest to the reckless writers to whom I have referred that they should acquaint themselves with facts in the first instance, and that they should gravely consider whether systematic detraction of their country and depreciation of its credit is a patriotic proceeding. Only last week I read that "Manchester is generally believed to have killed the cotton industry in India, and having killed it, it resolutely sets itself up against any attempt that may be made to revive it." Probably this statement is widely, if not "generally believed." What are the facts? In ten years this killed industry has increased the number of its mills from 190 to 232, and of spindles from $4\frac{3}{4}$ millions to very nearly 6 millions. There has been a further considerable increase since these statistics, which are available to every editor, were published. The cotton mill industry is just now suffering everywhere

LAYING THE FOUNDATION STONE.

from the high prices of the raw material, and India is not specially feeling the strain. Even at present prices, profits are possible, and as the demand for cotton goods is one that must steadily increase, we may confidently hope for good times in the future.

Indian Prosperity.

And meanwhile the ill wind is bringing prosperity to large numbers of cultivators, and is contributing to the general good. In one district of this Presidency six lakhs of revenue have recently been paid into the treasury in gold, which I believe is a unique experience. In ten years the deposits in the banks of India increased from 21 crores 69 lakhs to very nearly 48 crores, and the cash balances from 6 crores 3 lakhs to 12 crores 81 lakhs. If we turn to the output of natural resources, we find that in ten years the production of coal increased from 6,118,000 tons to 11,870,000 tons and more than doubled in value, that manganese increased from 139,000 tons to 500,000 tons, that gold increased from 513,000 oz. to 673,000 oz., that petroleum increased from $37\frac{3}{4}$ million gallons to more than $233\frac{1}{3}$ million gallons. In the same period, the number of joint stock companies increased by 816—from 1,340 to 2,156, and their paid-up capital from £23,100,000 to £38,000,000 sterling. Meanwhile the total area under sown crops increased from 180 million acres to 218 million acres. And this has happened in a country which we are told was once prosperous beyond all dreams and is now being rapidly reduced to ruin. Well might our esteemed Sheriff of Bombay declare four years ago that "it is the conviction of brokers, merchants, tradesmen and captains of industry that India is slowly but steadily advancing in material prosperity and for the last few years it has taken accelerated pace."

I fear that you may think these reflections irrelevant to the present occasion. We have, however, met to inaugurate an undertaking remarkable not only for what it will accomplish, but because it holds out the promise of economic developments of the highest future importance to India. Perhaps therefore my brief indication of progress in the past may not be out of place. The figures which I have quoted do not discriminate between Swadeshi enterprizes and those carried out with British capital. The late Mr. Justice Ranade, who was a sane and true Indian patriot, was well aware of these facts, and quite recently Mr. R. N. Mookherji, in the Industrial Conference at Allahabad, offered some wise remarks on the question of the introduction of foreign capital, and condemned the amazing theories which have found ready credence in some quarters.

"An important consideration for us in India," he said, "arises from the fact that, for our good, it is wise to allow British capitalists to interest themselves in our industries and thus to take an active part in their development."

Latent Indian Capital.

This view is beyond controversy; but at the same time it need not be forgotten that, where a country possesses available capital of its own, there are real and obvious advantages in employing such capital in preference to borrowing from abroad. Even if some estimates are excessive, it is beyond all doubt that

there is a vast amount of capital in India, and while happily we can discern a growing tendency to apply it to industries and to feeder railways, a huge amount remains latent and infructuous. To turn this capital to the development of India should be the aim of every true patriot. Here is an object which the instructors of the people may well place before their readers. The futile boycott proceedings have led only to fraud and ill-will. Since they were inaugurated in 1905, imports exclusive of Government Stores and Treasure, have risen from nearly 64½ millions to more than 80¾ millions sterling in value, and the introduction of foreign sugar, which was specially aimed at, has grown from nearly 7 millions cwt. to more than 12 millions cwt. The moral is plain for all to read. The true Swadeshist must give active help to Indian enterprizes and must encourage by example and precept the investment of idle capital in sound schemes which will help the advancement of India. It is this great object which has brought us all together to-day. Sir Dorab Tata has given an interesting account of the inception of this great work, and has told us how his father long ago realised the advantages of cheap power derived from water and sought the means of placing it at the disposal of his countrymen. When 10½ years ago the late Mr. Gostling propounded a practical scheme for supplying Bombay with power, Mr. Tata instantly saw the possibilities, and then commenced the proceedings which his son has brought to a successful conclusion. That a perfectly sound project should take so long in reaching the stage of execution may seem strange; but in India we are deliberate, and I am inclined to think that the delay has been an advantage.

Swadeshi Enterprise.

Had an earlier beginning been attempted we might not have seen the accomplishment of a purely Swadeshi enterprize. From the time of my arrival in India I was captivated by this great scheme, and it was my great wish, as I said at Sholapur, that it should be carried out with Indian capital. Quite apart from other considerations, promotion is a very expensive business, and if the necessary capital could be found in India without the assistance of London methods, it was certain that much money could be saved. Sir Dorab Tata knows that we had hopes and fears till a time came at last when he could tell me that the way was clear, and that a great Indian enterprize could be carried out with Indian financial resources. This is owing in great measure to those Ruling Princes who have shown in practical fashion their full trust in the future of their country, their anxiety for its progress, and their total disbelief in the baseless hypothesis of a steadily decaying India.

The Soundness of the Dams.

And now before I go on, I should like to say a few words about a point which has been laid before me this afternoon. Some doubts have been raised about the soundness of the foundation of this dam. These doubts are said to spring from the failure some years ago of a small dam at Sakhar Pathar. There is, however, no comparison between the circumstances of the two dams. At Sakhar Pathar a peculiar formation was met with, which is found at only one other place in the neighbourhood, near the foot of the Ghaut. That formation allowed the water to escape through the bottom. Here there are no such difficulties. On the other hand,

there is no doubt that the foundations of this dam are exceptionally favourable. They are much sounder even than those of Kadakwalsa, of which no one now entertains any doubts. Only an earthquake could shake this dam, and fortunately this region is not subject to earthquake.

The Electric Drive.

I do not wish to weary you with technical details; but there are a few points on which it is necessary to dwell. Sir Dorab Tata has indicated the special advantages of the electric drive, and they are now beyond all question. There is, however, an economic factor in the case of Bombay which should not be forgotten. I believe that the Lascashire millowner pays about 7 shillings and 6 pence per ton for his coal, while his competitor in Bombay has to pay about 20 shillings and 9 pence for coal of 10 per cent. less calorific value. In spite of this low charge for coal the Lancashire millowners are perfectly ready to instal electricity at from 0.5*d*. to 0.75*d*. per unit. How much more advantageous will it be to the Bombay mills to obtain their driving power from this Hydro-electric Company at 0.55 annas per unit free of all charges for motors and their maintenance! The determination of cost per horse-power hour requires great care, and I am well aware that different calculations are sometimes forthcoming; but, in 1904, the Agents of the Southern Maratha and the G. I. P. Railways reported figures which are in close agreement. The former stated that in the Hubli Workshops the cost was 1 anna, using Singareni coal, and the latter arrived at 1.01 anna with ordinary Indian coal. The Tata price of 0.55 anna per unit is the equivalent of 0.41 anna per horse-power hour, and is therefore well under one-half of the cost of steam as independently estimated by these two Companies.

Bombay's Requirements.

Turning to the requirements of Bombay, existing undertakings, not including trams, railways and the large future needs of the Port Trust, absorb about 90,000 horse power, and Government have pointed out that the electrification of the B. B. and C. I. Railway from Bandra to the South ought to be undertaken in the near future. But Bombay, the city that was to be "built with God's assistance," is a growing organism full of vigour and enterprize, with an unrivalled position as the great gate of the East, and with a future before it of which even the far-seeing Gerald Aungier could have formed no conception. What can be so certain as that within a few years Bombay will require far more electrical power than this scheme can provide? The Cauvery Works, with a total capacity of 13,000 horse-power, which owe their existence to the wise foresight and enterprize of the Government of His Highness the Maharaja of Mysore, return more than 14½ per cent., and their total net profit up to June last amounted to 77.54 of the capital expenditure. If the cities of Bangalore and Mysore and the Kolar Mines Section can easily furnish such profits as these, who can doubt the success of a scheme which caters for the greatest mill industry in India and for the manifold requirements of the most vigorous city in Asia? Surely its only fault is that it is too small; but I understand that the whole of the work which will now be carried out will be required for the larger scheme to which Sir Dorab Tata has alluded, though it must generally happen that expenditure is saved by the continuous execution of such great undertakings as this.

The Smoke Nuisance.

There is one necessary result of the application of electrical power on a large scale in Bombay to which I must refer. We are all proud of our noble city; but at the same time most of us bitterly regret the destruction of its natural beauty by the heavy hand of man, and we feel that enlightenment and smoke do not well accord. The question is a thorny one; but the facts are not in dispute. Bombay is in parts as dirty as London, and but for its climatic advantages it would be infinitely more befogged. Now, if 30,000 electrical horse-power replaced the equivalent of coal for 300 days of an average of 12 hours in the year, the consumption of the latter would be reduced by about 96,000 tons, or 320 tons per day. The combustion of this amount of coal has the effect of vitiating nearly 2,000 million cubic feet of air every day. I hope these figures convey something to your minds. I confess that they convey nothing whatever to mine; but at least we may all agree that the absence of this stupendous daily pollution of the air we breathe would be good for our constitutions, and must go far to restore the lost beauties of Bombay.

Ladies and gentlemen, we are perhaps too much accustomed, in this materialistic age, to apply purely commercial standards to undertakings of all kinds. Yet the effects of such a project as this may and will range far beyond anything that can be recorded in ledgers or evaluated in statistics. Consider the great railway systems of India. We may regard them simply as commercial concerns the value of which is sufficiently tested by the ratio of their earnings to their expenditure. We may condemn them if their dividends fall off and extol them if they yield ample returns. The statesman, the philosopher and the true economist, however, know well that such a test is practically worthless and that even an unproductive railway may be indirectly profitable in the best sense and may be a harbinger of future prosperity on a large scale. Clearly it is possible to build a useless line; but, with evidence all round us of what has happened in India, one reads with blank amazement that the railways are actively employed in draining her resources and are helping to bring about the rapid impoverishment of the country. It would be most unfair to regard these fantastic theories as representing Indian opinion. On the contrary, Government is perpetually being urged to further railway construction by people who well know what communication means to an isolated district, and as I have said, Indian capital is being attracted to railway enterprize, I cannot attempt to analyse what railways have done and will still do for India, economically and politically. It is to them that we owe the power to deal with famines and to prevent the wholesale loss of life which occurred in earlier days. To them is in great measure due what is healthy and encouraging in Indian unrest. And if, as we hope, an Indian nation will in time arise out of the heterogeneous peoples of this country, the result will be brought about largely by railways and would be impossible in their absence.

Immense Possibilities.

I have alluded to the hygienic and aesthetic importance to the city of Bombay of the introduction of electric power on a large scale; but many other consequences will follow, the indirect effects of which upon the life of the people are incalculable. If, in times of pressure, night shifts were required in the mills, I understand

that power could be supplied at 0.33 anna per unit. It is possible that, at some future date, an eight hour working day may prove desirable and even profitable. If that time ever comes, electricity will make the change practicable. Electrical power lends itself perfectly to minute sub-division, and thus to the development of a host of small industries which would add to the activities of Bombay. As a by-product of this scheme, there will be a very large quantity of water daily available for bleaching and dyeing mills, of which there is need, or for irrigation, and for drinking purposes. I have not exhausted the possibilities and I cannot attempt to forecast the indirect results which will flow from the apparently simple process of storing the now wasted monsoon rainfall in these Ghauts. Sufficient to say that a fresh impetus will be given to our great capital city and that thousands will feel its effects in ways infinitely varied. What most appeals to me is that we are to-day providing an object lesson which, without immodesty, we may hope will be learned beyond the boundaries of our Presidency. Here is a great Swadeshi project rendered possible by the trust of Indians in the future of their own country. That is surely a political object lesson of real importance. An investor naturally and rightly looks to dividends ; but that does not exclude patriotic motives, and when one thinks of what could be done towards the development of India by means of capital now idle, one may well derive hope and encouragement from this day's ceremony. Educated Indian opinion should be better able to arrive at a just judgment of the soundness of Indian projects than London financiers, and the advantages of the fructification of Indian capital in India are manifest. Such an enterprize as this, so entered upon, symbolizes the confidence of Indians in themselves, their willingness to be associated with a project somewhat novel in this country, and their assurance of the political stability which alone can guarantee the continued advancement of India. I know that I speak for you all in congratulating Sir Dorab Tata in bringing this scheme through many vicissitudes to the stage of accomplishment, in confidently wishing it the fullest measure of success, and in paying a tribute to the memory of that great pioneer of Indian enterprize Mr. Jamsetji Tata. It will fall to my successor to inaugurate the completed works, which will connect these valleys with the destinies of Bombay and add greatly to their natural beauty and to the importance and prosperity of Lonavla. Meanwhile my wife and I are proud to be associated with the first structural beginnings of a fine project which will I am convinced, have far-reaching results, moral and material, for the benefit of the people who have been my kind friends ever since I arrived among them, and whose prosperity and happiness is my most earnest desire.

Vote of Thanks.

Mr. Shapurji Broacha, Sheriff of Bombay and a Director of the Company, in proposing a vote of thanks to Their Excellencies said,—I have been honoured with the privilege of proposing a vote of thanks to His Excellency the Governor and Lady Clarke. Lady Clarke, who has been among us a short time, has, by her kindly and courteous demeanour, endeared herself to the classes and the masses by her enthusiasm in the cause of education without distinction of religions, creeds and castes, by her deep interest in all kinds of charity and charitable institutions. We know how dull some of these functions are, but she has stinted at no labour and shirked no fatigue to attend them all, making them obligations of duty, and no obligations of duty could be cheerfully and earnestly performed unless they have a spontaneity in the gooodness of the heart. Lady Clarke has put us under another obligation by making an environment of love and sympathy around the large life of the Governor, for Governors are human like ourselves. To be smiled and cheered on at successes, to be encouraged at great efforts, and to be sympathized with in cases of disappointments or failures brought about sometimes by misapprehension of motives with malice aforethought and sometimes through ignorance ; then nothing comes so sweet as sympathy from one near and dear to our heart.

That larger life of her husband is wholly and solely devoted to the material, moral and intellectual advancement of the people of this presidency. However much we may differ from the measures of the Government, I can say without fear of contradiction that His Excellency, since the day he landed on these shores, has gone straight in the path of duty without looking to the right or to the left, and when he has looked at either side, it was to find himself straight and true, oblivious of the praises and censures which must alternate in a people of many races, of different and almost antagonistic religions, with diverse hopes, aspirations and curvatures of thoughts. But the time is not yet to sum up. What I am at present concerned about is that my admiration as a broker is in conflict with my duty as a good citizen. What Bombay and the Bombay Presidency has gained in His Excellency the Governor, the world of high finance has lost. I can assure you that our Governor has the makings in him of a great promoter of vast enterprises. He has the intuitive genius of tapping resources hitherto unconceived. I can assure this assemblage that were it not for the Governor this successful promotion of Swadeshi enterprise would not have taken place to-day. It would have been hung up, or to use a slang expression, it would have "stuck in the mud," or it would have been so profusely watered by London syndicates that the really paid-up capital would have looked like an object looked at from the wrong end of the telescope. I thank Your Excellency and Lady Clarke for your coming down here to-day to perform the inaugural ceremony on behalf of the agents and my colleagues. I also thank this large assembly for coming to meet His Excellency the Governor and Lady Clarke. I ask you now to give three cheers to His Excellency the Governor, and three cheers to Lady Clarke.

List of Guests at the Inaugural Ceremony, Lonavla.

Sir Adamji Peerbhoy, Kt.
Hon. Mr. Abdul Hussein Adamjee Peerbhoy.
Mr. H. A. Armstrong.
,, C. H. Armstrong.
Mrs Armstrong.
Mr. George Ashby.
,, W. M. Anderson.
The A. D. C. in waiting on H. E. the Governor.
Mr. E. C. B. Acworth.
Mrs. Acworth.
Mr. E. F Allum.
Mrs Allum.
Mr. R. G. Abbott.
Mr. J. Black.
„ T. W. Birkett.
Mrs. Birkett.
Mr R. B. Baman-Behram.
,, J. Begbie.
,, J. Black.
„ A. J. Bilimoria.
„ J. F. Bradbury.
,, Shapurji B. Broacha.
,, Sorabji H. Bottlewala.
Mrs Bottlewala.
Sir Balchandra Krishna
Mr. Joseph Baptista.
„ H. J Bhabha.
Mrs. Bhabha.
Mr. Bejonji Dadabhai.
, S. R Bomanji.
,. J. H. Bhabha.
Mrs. Bhabha.
Mr. Robert Barlow
Mrs. Barlow.
Mr. Hormusji Edalji Bamjee.
Major-Genl. C St. L. Barter
Mr H. A. W. Brent.
Mrs. Brent.
Baron von Boddein
Baroness von Boddein.
Mr. Dadabhai C. Broacha.
„ R. H. Bottlewalla.
Mrs. Bottlewala.
H. E. the Hon. Sir George Sydenham Clarke.
Lady Clarke.
Hon. Mr. G. L. Cameron.
Mrs. Cameron.
Hon. Mr. G Carmichael.
Mrs. Carmichael.
Hon. Mr. M. B. Chaubal.
Monsieur L. Combe.
Madame Combe.
Monsieur J. DeCourtois.
Mr. P. R. Cadell.
,, Hormasji Commisariat.
Mrs. Commissariat
Mr Churturbhuj Gordhandas
„ Cowasji Jehangir.
,, A. T. Cooper.
,, W. A. Chambers.
Mrs. Chambers.
Hon. Mr. G. S. Curtis.
Mrs Curtis.
Mr. Merwanji M. Cama.
,, Hormusji M. Cama.
,, W G. Clabby.
Lt -Col. M. A T. Collie.
Mrs. Collie.
Mr. T. D. Parry.
Mrs. Parry.
Mr. R. H. Campbell.
„ Alderman E. E. Cooper.
,, Cheniram Jasraj.
Hon. Sir Sassoon David.
Hon. Mr. Justice Davar.
Mr. A. K. Donald.
Viscount De Wrent
Mr. E. H. Dennison.
Mr. Dharamsey M. Goculdas.
Dr. K. E. Dadachanji
Mr. J. A. Dalal.
Captain E. G. Drummond.
Mr. P. V. R. Deshmuk.
„ Alfred Dickinson
„ Pirosha M. Dalal.
Mrs. Dalal.
Mr. I. David
Mrs. David.
Mr. S. M. Edwardes.
Mrs. Edwardes.
Editor, Bombay Samachar.
,, Jam-e-Jamshed.
„ Akbar-e-Sodagar.
„ Sanj Vartman.
„ "Indian Industries and Power."
,, "Deccan Herald."
Mr. J. E. Ezra.
„ E. Ezra.
„ A. F. Modi.
„ R. Cauty.
Hon. Mr. Fazulbhoy C Ebrahim.
Mr. Fazulbhoy J. Lalji.
„ R. Furugori.
,, C. H. B. Forbes.
„ A. F. Fergusson.
„ P. J. Fitzgibbon.
Mon. L. C. M. P. Barret. French Consul.
Major J. G Greig.
Cavaliere Dr. G. Gorio.
Madame Gorio.
Hon. Mr. H. R. Greaves.
Mr. M. M. Gubbay.
„ John Greig.
„ Gordhandas Khattau.
,, F. F. Gordon.
„ W. Turner Green.
,, Jivaji D. Gandhi.
„ H. P. Gibbs.
,, A. R. Burch.
H. H. Uvraj Shri Bhojrajji of Gondal.
H. H. Uvrani of Gondal.
Mr. Govindji Madhowji
„ R. Gilbert.
„ B. Godbole.
,, J. E. B. Hotson.
„ A. Mill, C.I.E.
„ R. T. Harrison.
„ Hurgovindas Mulchand.
„ P. A. Hormusji.
„ Haji Yusuf Haji Ismail.
Major H. A. L. Hepper, R E.
Mrs. Hepper.
Mr. B. H. Hewett.
„ A. Hydari.
Mrs. Hydari.
Hon. Mr. Ibrahim Rahimtoolla, C.I.E.
Mr. K. Iwasaki.
„ D. M. Inglis.
„ N. Igarashi.
,, E. H. Ingle.
Sir Cowasjee Jehangir, Bart.
Mr. Jehangir D. Framji.
Mrs. Jehangir.

Sir Jamsetjee Jeejeebhoy, Bart.
Lady Jeejeebhoy.
Mr. Jafferbhoy Rehimtulla.
„ R. B. Joyner, C.I.E.
„ Byramji R. B. Jijibhoy.
Mrs. B. R B. Jijibhoy.
Mr. C. Percy Jones.
The Very Rev. H. Jurgens, Archbishop of Bombay.
Khan Bahadur Syed Miyan Kadri.
Mr. P. E. Keene.
„ J. Knowles.
„ K. Kodama.
„ R. J. Kent.
Dr. N. N. Katrak.
Mrs. Keatinge.
Mr. Douglas Kerr.
Hon. Mr. R A. Lamb, C.S.I., C.I.E.
Hon. Mr Lalubhai Samaldas.
Mr. R C. Lees.
„ A. K. Leslie
Mrs. Leslie.
Mr. J B Leslie-Rogers
„ H. F. Carvalho.
„ F. N Church.
Rev. A. De Monte.
Mr. J. S. Latimer.
H H. Thakor Saheb of Limbdi
Principal O. V. Muller.
Mrs. McCausland.
Mr. F. E. Messent
„ P. G Messent.
Hon. Mr. W. T. Morison, C.S.I., I.C.S
Mr. N. A. F. Moos
Mrs. Moos.
Hon Mr. Manmohandas Ramjee
Mr. Mahomedbhoy Ebrahim.
„ J. S. Wardlaw Milne.
Mrs. Milne.
Mr. Mahomedbhoy Adamjee Peerbhoy.
„ Mulraj Khattau
„ Mahomedbhoy Hajee-bhoy Laljee.
„ Mirza Mahomed Shirazi.
„ James MacDonald.
Mrs. MacDonald.
Mr. N. H. Matheson.
H H. The Maharajah of Mysore.
H. H. Prince Yuva Raj of Mysore.
Khan Bahadur M. C. Murzban, C.I.E
Mr. Stuart Monteith.
Mons. S. Mahmoud Bey, (Vice-Consul, Turkey).
Mr. N V. Mandlik.
„ V. P. Madhava Rao, C.I.E.
„ H. M. Mehta.
„ S. A. Nathan
„ Narottam Morarjee Goculdass.
„ K. Natarajan.
Hon. Dr. Tehmulji B. Nariman.
Mr. R. M. Nissim.
„ Nanabhoy Tullockchand.
„ G. Owen Dunn.
„ J. P. Orr, I.C.S.
Mrs. Orr.
Mr. H. R. Oomrigar.
„ O C. Ormsby.
Hon Mr. Goculdas Kahandas Parekh.
Mr. E. M. Proes.
Mrs Proes.
Hon Sir Henry Procter.
Sir Dinshaw Petit.
Lady Petit
Mr. Bomanji Dinshaw Petit.
Mrs. Petit.
Mr. Jehangir Bomanji Petit.
Mrs. J. B. Petit.
Mr. Manockji C. Petit.
„ G. C. Plinston.
„ Rustom S. Powala
Mrs. Powala.
Mr. Kavasha S. Powala.
Mrs. Powala.
Mr. P. D. Pattani C I E.
„ N. M. Purvez.
„ P. A. Paris.
„ T. D. Parry.
Mrs. Parry.
Rt. Rev. E. J. Palmer, Lord Bishop of Bombay.
Hon. Mr. L. J. Robertson.
Mrs. Robertson.
Mr. F. T. Richards.
„ A. J. Raymond.
„ L Robertson.
Dr. Stanley Reed.
Mr. S. M. Rutnagur.
„ H. L. Richardson.
„ Ramnarayan Harnandrai.
„ F. C. Remington.
„ B. D. Richards.
Mr. Ratanji Dharamsey M. Goculdas.
„ J. Rodgers.
„ W. Roberts.
Major-General J. C. Swann, C. B.
Mrs. Swann.
Mr. E. L. Sale.
Mrs. Strangman.
Mr. J. Sanders Slater.
„ P. L. Sprott.
„ J. L. Symons.
„ N. B. Saklatwalla
Mrs Saklatwalla
Mr. Shapurji Sorabji.
„ W. N. Shilstone.
„ K Sasaki.
His Excellency C. N. Seddon, I.C S.
Mr. R. D. Sethna.
„ D S. Shellim.
Lt.-Col. J. Smyth, M.D., I M S.
Mr. Z. Sekine.
„ L. C. Swift. I C.S.
Count E. Von Thurn.
Countess Thurn.
Hon. Sir Vithaldas D. Thackersey.
Mr. A. M. Tod.
„ R. D. Tata.
Mrs. Tata.
Mr. M. A. Tana.
Sir D. J. Tata, Kt.
Lady Tata.
Dr. Morris W. Travers.
Mr. E. Ueda.
Rao Bahadur Vasonjee Khimjee.
Mr. V. Y. Vanikar.
Dr. A G Viegas.
Mr. Vithaldas Samaldas.
„ N. Yoshii.
„ A. L. M. Wood, I C.S.
„ W. H. White, I.C.S.
Mrs. White.
Mr. N. N. Wadia.
Mrs. Wadia
Mr. D. E. Wachha.
„ J. Wallace, C.E.
„ J. Casson Walker.
Mrs. Walker.
Mr. J. Walker.
„ G. Wittet.
„ C. J. Willis.
„ J. P Watson.
„ C. Watanabe
„ Cursetji Pestonji Wadia.
„ V. H. T. Weekes.
Major Westmoreland.
Mr. Francis W. Wilson.

Extracts from Press Notices

The history of the origin and growth of the Ghaut Hydro-electric Scheme illustrates the fact that the co-operation and sympathy of Government are essential for the regeneration of India even in the matter of her industries.—*The Subodh Patrika.*

The enterprising Parsis, the richest community in India, have realised both the patriotism and the business. Our Chetties, who are next to the Parsis in point of wealth and enterprise, are apparently little concerned in patriotism and new methods. If they and the Zemindars happen to enlarge their horizon, the material prosperity of our country should be within our sight.—*South Indian Mail.*

His Excellency Sir George Clarke, Governor of Bombay, deserves the sincere thanks of all friends of India for the practical interest that he has been taking in our industrial progress. It is now well-known that his sympathy has been very great for the Tata Hydro-Electric Scheme; and this went a long way to induce our Princes and wealthy men to go in for shares in that concern.—*The Mysore Times.*

This city is deeply interested in the success of the undertaking which was inaugurated by His Excellency and cannot be too grateful to the great captain of industry, who conceived three grand projects with which his name will for ever be associated and to his enlightened sons who have maintained the traditions of their illustrious father by a loyal adherence to the principles and ideals cherished by him.—*The Gujarati.*

In Bombay the Government as well as the people have proved that honest Swadeshi has still ardent supporters and warm adherents, and Sir George Clarke may well claim that the Tata Hydro-Electric Scheme is an object lesson to the whole of India. While Bengal still hankers after a destructive boycott, Bombay has launched a magnificent constructive scheme of true Swadeshi. Bravo, Bombay!—*Comrade, Calcutta.*

The Tata Hydro-Electric Power Supply Company is a notable instance of an enormous swadeshi enterprise, the entire amount of capital, 175 lakhs of rupees, having already been taken up by Ruling Chiefs and Princes and capitalists of India. All these factors put together have produced the beginning of an undertaking which is of unparalleled significance for the development of industry in this Presidency and in all India.—*The Dyanodhya.*

In inaugurating the Hydro-electric works at Lonavla, H. E. the Governor laid considerable stress on the circumstance that the enterprise was supported by Indian capital. His Excellency, therefore, no less than the Tata family and others who have identified themselves with so great an enterprise, must feel proud of the near prospect of electricity being supplied at a cheap rate in Bombay and other places between Lonavla and the city.—*The Indian Spectator.*

The present scheme will work wondrous changes in the industrial life of Bombay, and the huge electric power it will store up can be utilised in numerous ways. Besides the material and immediate advantages of this hydro-electric scheme, its value in the industrial sphere lies in the fact that it will electrify the industrial spirit of India, and new energy will course through the veins of the body mechanic and stimulate it to action.—*The Mahratta.*

Messrs. Tata Sons and Co. are to be congratulated for the gigantic and pioneer schemes they have undertaken. The success seems quite assured and their utility no one doubts. The Iron Works at Kalimati and the Hydro-electric Works at Lonavla are large and typical industries of new India with its enormous economic possibilities for which nature has endowed her with ample materials. We hope that the example will be followed by others in India and that Indian enterprise, talent and capital, will combine to this end.—*The Madras Standard.*

The fruition of the great hydro-electric project which originated in the fertile brain of the late Mr. J. N. Tata may well fill the Indian mind with pride and satisfaction. When the project has become a fact, these Hydro-electric Works and the Iron and Steel Works now in course of completion at Kalimati will be probably the biggest and finest of Swadeshi industrial enterprises. And both owe their origin to the late Mr. J. N. Tata and their realisation to his worthy sons Sir Dorabji and Mr. Ratan Tata. The best organised cotton mill in all India is again Messrs. Tata's Empress Mills at Nagpur. The only science college in India which will bear mention along with the institutions of Europe, the country owes to the same illustrious and philanthropic family. Is it easy to express in words the sense of deep and abiding gratitude felt for them by the people of India, of all provinces and all communities ? May the Tatas always prosper, ever more and more, for the benefit to their motherland and fellow-beings !—*The Leader, Allahabad.*

A gigantic engineering feat, the magnitude and extent of which is not yet fully realised and, perhaps, could not be realised by imagination, is to be performed in Bombay, when the hydro-electric scheme comes to full working system. No enterprise undertaken in India with Indian capital has been of a more adventurous character, indicating great daring and far-seeing business talents, than the scheme to be soon in full operation. Great engineering skill has been brought to bear upon it. The result that is to follow is expected to do for Bombay what no undertaking could have done for it. A perennial supply of electricity at rates cheaper than possible otherwise, is the best aid to the budding industries of the day. The industrial spirit of Bombay will obtain considerable incentive by the availability, under very

encouraging conditions, of the requisite electricity to drive machinery. Several small industries would feel the touch of life, so that the scheme is not only an example of gigantic Indian enterprise in the field of industry, but also a powerful incentive.—*The Indian Patriot, Madras.*

The enterprise captivates our heart and imagination. But it must commend itself to all Indians as a truly Swadeshi enterprise, and on this aspect of the scheme his Excellency dwelt lovingly and in most felicitous terms.

It will do us good to remember at this moment the author, orginator and prime-mover of this enterprise, Mr. Jamsetji N. Tata. Sir Dorab's references to his father in his most interesting recital of the history of the scheme were marked by true filial piety. Mr. Jamsetji Tata has symbolized the best and highest type of patriotism. In the search for new enterprises, and in the making of costly experiments to test their merits in the beginning, he never flinched from incurring heavy expenditure. A true son of India, his one ruling desire was to devise means for the opening up of new fields of activity, and the enrichment of the country which must follow an extensive development of its resources. Sir Dorab and his brother have been treading in the footsteps of their father. What he conceived, they have been executing. The Hydraulic Scheme will stand as an everlasting monument to the Tatas—father and sons.—*The Sanj Vartaman.*

The event marks an epoch in the history of Bombay cotton spinning. Indian commerce has equal reason to be grateful to H. E. Sir George Clarke, whose unfailing interest has supported the undertaking through every crisis, and to Sir Sassoon David, but for whose timely guarantee much of the necessary capital would have had to be raised in London. The present undertaking, it may be mentioned, contemplates a supply of energy equal to about 40,000 I. H. P. delivered in Bombay, with a capital of Rs. 170 lakhs, while the annual revenue is estimated at Rs. 28 lakhs and the expenditure at Rs. 12 lakhs, leaving Rs. 16 lakhs net profit. By Sir Sassoon's guarantee the whole of this expenditure is covered for ten years, and the initial success of a scheme of such far-reaching promise for local industries is thus assured. It is possible that a larger project of some 70,000 I. H. P. may eventually be installed, since the immediate power scarcely suffices for one half of the Bombay mills, but in this event, though the annual revenue will probably increase to Rs. 50 lakhs, the expenditure will not exceed Rs. 15 lakhs. To realise the economic value of the hydro-electric scheme this expenditure has only to be compared with the total expenditure on the numerous existing steam plants in the Bombay cotton mills.—*The Pioneer.*

This great Ghaut project when materialised will be the last of the three sublime monuments to the memory of that wonderfully patriotic son of India, the late Mr. Jamsetji Nasarvanji Tata, who has been fitly described by a biographer as the "Indian Columbus" in the field of industrial enterprises. There have been other men in India more bountifully endowed by the goddess Lakshmi. There have been also great patriots who have dreams of vast industrial projects for the betterment of their motherland. But it was left to Tata alone to discover the

stupendous possibilities that awaited an enterprising financier and captain of industry in this country of vast natural resources and cheap human labour. Tata will be remembered as the first Indian in modern times, who saw that the dream of India, as a great industrial country, could be materialised if the energies of her children could be properly directed. Though he did not live to see his dreams fully fructify, it redounds to his everlasting credit that within six years of his passing away the huge Iron and Steel works in Bengal, the great Research Institute at Bangalore and the vast Hydro-electric project at Lonavla, each one requiring hundreds of lakhs of capital, should all of them be set on a working basis. Truly, Tata was a Titan, indeed, among the pioneers of industry in this land.—*Madras Standard.*

The year nineteen hundred and eleven will stand out as a red-letter day in the annals of the development of the city of Bombay. The scheme has been brought to its present stage of development by Indian intelligence and Indian capital, and that is a more significant political factor in the history of this country than that a few miles beyond the scene of the works a nest of sedition recently showed some activity. It expresses the confidence of the people in their institutions, and the existence of those settled conditions which capital demands before it will exert its energies. The laying of the foundation stone yesterday under the circumstances we have briefly recounted is good evidence of the political tranquillity of the country and the confidence of India's people in the future.

Mr. Jamsetjee Tata was a man who had a massive mind. He thought out immense projects as easily as other men work at simple problems. He has been dead for five years, only now three of his great schemes are ripening into maturity. It is only the other day that His Excellency the Governor of Bombay laid the foundation stone of the headworks at Lonavla which are to utilise the rainfall on the Western Ghauts in order to provide electric power for Bombay industries. For long India has held an important place in the world because of her vision. She has dreamed dreams. She has lived among the stars. When India hitches to the star a waggon of practical life and learning there will undoubtedly be a future for her mightier than even the past has been. India will make, within the next century, mighty advances in science and industry.—*The Indian Witness, Calcutta.*

The conditions of the hydro-electric scheme are such as to invest it with a patriotic as well as a commercial character. It is designed to benefit not an individual concern, but all industries in Bombay. Although some interested people may wrangle over the respective merits of the steam and electric drive, the question does not admit of argument. The electric drive, by virtue of its smoothness and regularity, is far better suited to cotton spinning than steam, and tends to produce better and more even yarn. Quite apart from all other considerations, the provision of cheap and abundant electrical power would give a great stimulus to the spinning and weaving industry that is the backbone of Bombay. But those other considerations are in themselves of enormous public importance. The smoke nuisance in Bombay is a great sanitary evil, poisoning the air and fouling the city with mephitic filth.

The ghat hydro-electric scheme would at once reduce this serious and growing evil to negligible proportions. Again, the provision of cheap electric power would not only benefit existing industry and cleanse the city, but it would induce a great extension of industry. By furnishing power, without the cost and labour of putting down a power plant, cheap electricity renders possible all sorts of industries which otherwise would be unprofitable.

The actual horse-power installed in the Island and the immediate vicinity is about a hundred thousand. Half of this would absorb all the energy generated by the hydro-electric scheme of the scale at present contemplated. But we can hear the croakers say :—"Will these power users take electricity." They are best answered in the words of an eminent American engineer when pestered by doubters,—"Sir, if you can put down electric-power at less than it costs to produce horse-power, don't you fret about selling it. Why, people have got to take it whether they want to or not."—*Times of India.*

Those who read Sir Dorab Tata's speech—a worthy son of an illustrious father—made at Lonavla yesterday, will have a complete knowledge of the details of the Hydro-electric enterprise. It is no doubt true that the inception of it was the effort of a man who thought of something more than the acquisition of wealth. The Research Institute, the Lonavla scheme and the Iron and Steel project place the late Mr. Tata in that congeries of men of no particular nationality such as Lesseps, Carnegie, Willcocks, Armstrong, Whitworth, &c., who have left their mark on the pages of industrial history, and had the rare capacity of thinking large. We are not claiming too much for Bombay when we place our own Captain of Industry in that group for he was a man of large ideas and undaunted courage in carrying them out. Naturally a project of so noble a character as the Ghaut Scheme appealed slowly to the capitalists of this country and as Sir Dorab told us, money was at first shy, but ultimately it has been financed in India, and there is the assurance that further capital will be forthcoming from the same source. But if Indian enterprise and Indian capital have accomplished this, Englishmen are entitled to take some pride in the fact that the successful issue of the long labours was due to the personal intervention of H. E. Sir George Clarke. Sir Dorab made a generous admission of this fact. If we desire other expert evidence we have it in the words of Mr. Shapoorji Broacha, who recently said : "It is the conviction of brokers, merchants, tradesmen and captains of industry that India is slowly but steadily advancing in material prosperity, and for the last few years it has taken accelerated pace." Sir George Clarke's speech yesterday collated a mass of facts, figures and information seldom put together in such an accessible form. They are worthy of careful study, and we trust they will be translated into the vernaculars and widely circulated.—*Advocate of India.*

The great hydro-electric power scheme, in connection with which Sir George Clarke laid the foundation-stone of extensive works at Lonavla last week, owes its inception to the prescience of the late Mr. Jamsetjee Tata. In some respects Mr. Tata was unquestionably the most remarkable Indian of his period. He had great foresight, exceptional courage, and the habit of spacious thinking, and he had

amassed sufficient wealth to enable him to start huge schemes. Though progressive in politics and a silent sympathiser with the aspirations of Indians for a greater share in the control of their own affairs, he saw clearly that the salvation of his country lay largely in the development of industrial enterprises. As a pioneer of Indian industry he stood entirely alone, and so far he has had no conspicuous successor. His articles of faith were that India could not subsist almost solely upon agriculture, that the country had vast unutilised resources, that with her abundance of raw material and cheap labour India might develop great manufactures, and that Indian brains and Indian capital, wisely associated, where necessary, with western experience, ought to do the work. For years he spent money and devoted his exceptional business capacity and his inexhaustible energy towards these ends. The boldness of his projects staggered and sometimes frightened his contemporaries, but his wisdom is gradually receiving posthumous justification. Whenever he conceived an idea, he sought the aid of experts and did not move further until its possibilities had been investigated with minute scientific exactitude. Though most of his enterprises were primarily conceived with a financial object, they were always associated, with the dominating idea of the betterment of India which lay ever at the back of his mind. Even his great land speculations in and around the city, which remained his principal home, were intended to assist the creation of a healthier and more beautiful Bombay. His mind was essentially practical. He asked why raw cotton should be brought to the coast to be manufactured, and established mills in the centre of the cotton-growing districts which are to-day a pattern of good management and success. He asked why India, in a great railway-building era, should buy vast quantities of steel rails from Europe. His agents scoured the country until they found iron ore and coking coal and limestone in fairly contiguous positions, and the extensive Iron and Steel Works now in process of creation at Kalimati are the result. He perceived that his countrymen needed training in the application of scientific research to modern industry, and gave nearly a quarter of a million sterling to establish an Institute of Science at Bangalore. He was a Parsi, and his interests centred in Bombay, but his spirit rose above the restraints of race and creed. He belonged to the whole country and did more for its regeneration than any other Indian of modern times.

This notable man, whose labours were so appropriately commended by Sir George Clarke, was long possessed by the thought that the heavy tropical rainfall of Western India might be utilised for practical purposes. Behind the narrow strip of coast the Western Ghauts rise like a natural rampart, and they catch the first onset of the south-west monsoon. The average rainfall in the Lonavla district is 175 inches. Mr. Tata hit upon the idea of constructing huge storage reservoirs amid the hills, and arresting the rapid flow of water to the sea. The water thus accumulated could, he contended, be converted into enough electric power to supply all the mills in Bombay. He was laughed at, but pursued his idea with characteristic tenacity of purpose. The preliminary investigations lasted for years, but it was conclusively demonstrated that the thing could be done, and Wednesday's ceremony marks the commencement of the work. The first estimate is for 30,000 horse-power, but this should ultimately be far exceeded. The capital runs into a million and a quarter sterling, but the most interesting feature of the scheme is that the money has been entirely subscribed by Indians, among whom are numerous

Princes. The promoters of the scheme, chief among whom are the sons of Mr. Tata, admit, according to our Bombay Correspondent, that without the support of Sir George Clarke and the Bombay Government it could not have been brought into practical form. At a time when the Indian authorities are too often reproached with indifference to the welfare of the country, it is well to recall how much the Tata undertakings owe to Government assistance. Generous help has been forthcoming alike for the Iron Works and for the Institute of Science.

. The larger lessons inculcated by this great enterprise in the Western Ghauts were well expressed by Sir George Clarke. In itself it is unusual enough to arrest attention, but its commencement has a broader interest because it is one of many reassuring signs lately visible in India. The men who unlocked their treasure to make the project possible plainly have no misgivings about the stability and permanence of British rule. They are unmoved by the disturbing symptoms which are sometimes visible, and are convinced both that British control will endure and that under its fostering care a great development of industrial prosperity can be achieved. That was the cardinal belief of the late Mr. Tata, and the lesson of his life and aims may suitably be emphasised afresh at this moment. We do not wish to belittle the efforts of those of his countrymen who, by legitimate efforts, are seeking to awaken the political instinct of their compatriots, but we believe he worked upon sounder lines. All the political activity of Bengal has never produced a single piece of solid achievement. The sham Swadeshi schemes have become mere wreckage, and the 'National' educational institutions are something worse than a mockery. Here, on the other hand, is a genuine Swadeshi project, in which level-headed Indians have worked hand in hand with the Government. It is one of the harbingers of that widespread industrial development upon which India is now slowly entering. Every such enterprise brings others in its train. The great mill industry, despite its vicissitudes, has furnished an accumulation of capital which is now being used in other directions. India still needs English capital and it is surprising that she cannot obtain more of it; but every productive scheme which is financed in India is a strong additional assurance of stable conditions. The opportunities of economic progress are endless. The seas of India swarm with fish, yet she imports large quantities of salted fish. She exports huge consignments of hides and skins which she ought to be manufacturing into leather. She buys millions of pounds' worth of sugar which she ought to grow herself. She imports large quantities of matches which might be made on the spot. She could make much more of her own paper and soap and earthenware. She sends raw materials for paint and varnish all over the world and buys back the manufactured article. She has only lately found that she can weave cloth of a quality which she was too long content to purchase elsewhere. When some of these economic anomalies are remedied, when Indian capital is abundantly poured forth to supply Indian requirements, when the growth of prosperity brings definite advantages, we shall be brought far nearer a period of widely diffused contentment in India than will ever be rendered possible by the use of political nostrums alone.—*The Times* (*London*).

Further Progress: Application for Power.

The Tata Hydro-electric Company invited applications for energy from millowners and the general public on July 8th, 1911, and on the date fixed—August 2nd, 1911, the whole of the available power was taken up by,

Hon. Sir Sassoon David, Baronet	Hon. Mr. Herbert Rufus Greaves
Sir Shapurji B. Broacha, Kt.	Mr. Haji Usaf Haji Ismail
Hon. Mr. Fazulbhai Currimbhoy	Hon. Sir Vithaldas Thakersey, Kt.
Mr. John Frederick Bradbury	Mr. D. M. Inglis
Sir Cowasji Jehangir, Baronet	Mr. Mathuradas Gokuldas
Mr. Sorabji Batliwala	Mr. Rustumji B. Jijeebhoy

With the exception of two flour factories the power will be utilised entirely for 26 cotton mills. The Tests for the requirements of each mill have been made, showing an aggregate of 1,170 I. H. P. for the two flour mills and 32,925 I. H. P. for the 26 cotton mills, as under,—

Cotton Mills to be Electrically Driven.

	I. H. P.		I. H. P
Apollo	885	Jamshed	825
Bombay Cotton	935	Jubilee	795
Crescent	1735	Mahomedbhai	1330
Colaba Land	1475	Madhawji Dharamsee	1580
Crown	575	New City of Bombay	1250
Currimbhai	1200	New Great Eastern	1560
David (1) }	2450	Phoenix	1790
David (2) }		Ripon	1220
Dawn	1320	Sun	1100
Ebh. Pabaney	1460	Standard	1715
Elphinstone	1795	Sorab	265
Fazulbhai	2215	Swan	1360
Gold Mohor	880	Western India	1210

Flour Mills to be Electrically Driven.

Bombay Flour Mill, 755 I. H. P. Union Flour Mill, 415 I. H. P.

Rates and Charges.

Cotton mills Indicating 600 or more horse power and requiring not less than 300,000 Board of Trade units per quarter annum under contract for a period of ten years, will receive electrical energy for power application, at the rate of ·55 anna per unit, the electric driving plant being installed and maintained by and at the cost of the Tata Company. A special charge of 1.25 anna per unit will be made for electrical energy used for lighting purposes by mills which use the power from the Company's mains.

Contracts for the Works.

Details of the reservoirs, the hydraulic works, the generating plant and transmission lines, etc., have been published on pages 17-19. Reference will also be found on page 21 to contracts and tenders for the works. Further progress has however been made since those pages were printed, the following being a more up-to-date list of the contracts for the complete works, for delivering approximately 30,000 H. P. in Bombay.

The construction of the Lonavla and Wahlwan reservoirs and duct lines has been entrusted to Messrs. Pauling and Company, of London, for Rs. 40,50,000 or £270,000. The pipe lines and pen stocks will be supplied by Messrs. Escher Wyss and Company, Zurich, at a cost of Rs. 14,85,000 or £99,000, and also the Turbines coupled direct to Generators by Messrs. Siemens Brothers Dynamo Works, London. The cost of the Turbo-generator sets and the Excitor sets will be approximately Rs. 4,05,000 or £27,000. Messrs. The General Electric Company of New York have been entrusted with the order for the 100,000 volts Transformers, valued at Rs. 1,65,000 or £11,000. The Insulators (100,000 volts) and Steel Towers for the transmission lines from Khopoli to Bombay (43 miles) will be supplied by Messrs. Bullers Limited of London, for Rs. 2,47,500 or £16,500, and the copper Conductors by Messrs. Felton and Guilleaume Cable Works, for Rs. 2,70,000, or £18,000, including cost of erection. The plant at the Receiving Station will be supplied and fitted by Messrs. The General Electric Company of New York, for Rs. 4,05,000, or £27,000, the underground cables and distributing mains being furnished by Messrs. The Callenders Cable and Construction Company, Limited, London, for Rs. 9,75,000 or £65,000.

The total cost of the present works may be roughly stated as under:

Hydraulic Works including Duct Lines	£2,70,000
Pipe Lines and Pen stock	99,000
Turbo generators and excitors	27,000
Transformers for Power Station	11,000
Switch gear for Power Station	12,000
Steel Towers and Transmission Line	34,500
Transformers for Receiving Station	11,000
Switch gear for Receiving Station	17,000
Underground Cables and Mains	65,000
Electrical equipment of mills (estimated) ...	80,000
Buildings for Generating and Receiving Stations..	20,000
Sundries	3,500
Total	£6,50,000

Progress of the Works.

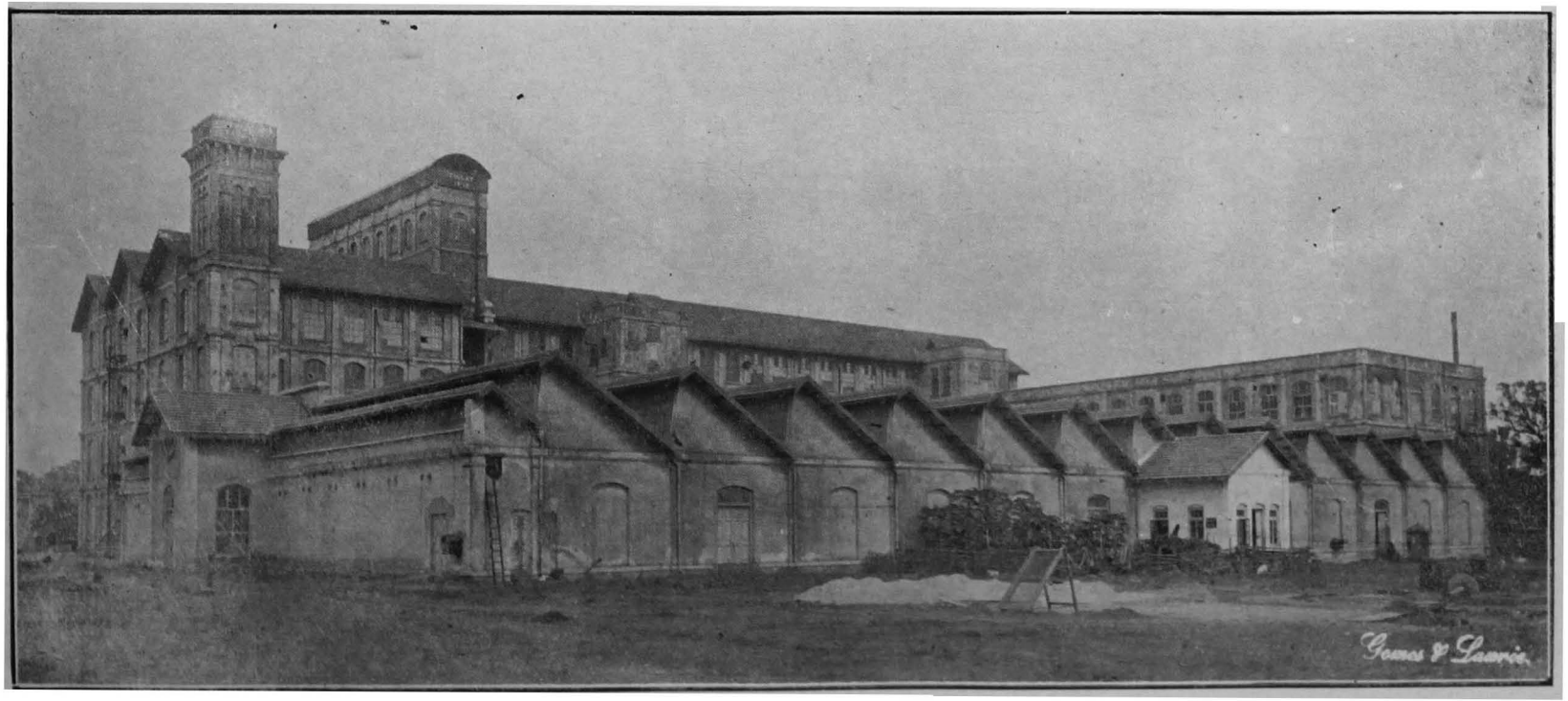
The progress (April 1912) of the Works has been satisfactory. A large portion of the excavation has been completed, and the construction of the dams will have advanced far enough by the end of May to enable the contractors to hold about 12 feet of water in the Whalwan and 15 feet in the Lonavla lakes at the end of the coming rains; this supply will materially facilitate the masonry work on the dams during the next dry season. The staff quarters have been erected on a site near the Power Station at Khopoli; the foundation work for the high tension transmission line across the Thana Creek has been taken in hand, and contracts for the different sections of the electrical plant, machinery etc., have been placed. The power tests for each of the 28 factories to be driven electrically, have been completed, the tenders and prices for the motors, meters etc., being now under consideration. The work of electrification will be taken in hand about December, 1912, it being arranged to instal alternating current motors running from 350 to 750 revolutions per minute in the cotton mills. About 200 motors will be required, for the 26 mills, the average horse-power per motor being estimated at 250, the voltage 6,000, and the periodicity 50 cycles per second. The underground mains in Bombay have been laid along a large section of the route of the contracting mills, and it is expected that energy will be ready for delivery about the beginning of 1914.

Future Developments.

There are 83 mills in Bombay (including Coorla) with 932,630 mule and 1,891,370 ring spindles, or total 2,824,000 spindles; of these 46 are weaving mills containing 42,000 looms. The approximate steam power for the 2,824,000 spindles would agregate 71,000 I. H. P. and for the 42,000 looms, 14,000 I. H. P. or a total of 85,000 I. H. P., not including power required for bleaching, dyeing and finishing. Of this 85,000 I. H. P., the equivalent of only 35,000 I. H. P. will be driven electrically by energy from the Tata Hydro-electric Company's mains, leaving 50,000 I. H. P. to be electrified either by an extension of the works at Lonavla or by private generating plants.

The Caxton Printing Works, Bombay: THE FIRST ELECTRICALLY DRIVEN PRESS IN INDIA.

The Caxton Works where the *Indian Textile Journal* is being printed, are the first complete Printing Works in India designed and laid out for the Electric Drive.



THE FINLAY MILLS, BOMBAY: THE FIRST ELECTRICALLY DRIVEN SPINNING AND WEAVING MILL IN INDIA.

The Finlay Mills were the first in India to be designed and laid out for the electric drive. The machinery consists of 30,000 spindles and 600 looms, the latter being supplied by Messrs. Wm. Dickinson & Sons. The current is produced on the premises by Diesel Engines coupled direct to Westinghouse Generators, the machinery being driven by motors connected to the line shafts. The whole of the electrical equipment and the shafting and gearing were designed by Messrs. Bradbury, Brady & Co, Bombay, and have proved a great success.

Cotton Spinning and Weaving Mills in Bombay.

The spindles and looms are taken from the Millowners' List. The I. H. P. is based on 40 spindles to one Horse Power and 3 looms to one Horse Power.

Agents.	Mills.	Spind.	Looms.	I.H.P.
Hormasji Sorabji & Co.	Jamshed	28,910	297	820
	Sorab	8,540		210
	Bom. Cotton	28,070	606	900
		65,520	903	1,930
Sassoon J. David & Co.	David (1)	28,120		700
	David (2)	40,530		1,010
	Dawn	37,490		940
	Standard	43,150	1,172	1,470
		149,290	1,172	4,120
Greaves, Cotton & Co.	Apollo	42,500		1,060
	Connaught	32,760		820
	Empress	34,120		850
	New Empress	41,820		1,040
	How. & Bull.	43,820		1,100
	Imperial	36,430		910
	Jas. Greaves	38,120		950
	Leopold	13,370		340
		282,940		7,070
E. D. Sassoon & Co.	Alexandra	29,350	734	980
	Ed. Sassoon	45,400		1,130
	E. D. Sassoon	52,670	843	1,600
	Jacob Sassoon	95,800	2,079	3,100
	Meyer Sassoon	20,930		520
	Rachael		2,009	670
		244,150	5,665	8,000
Bradbury, & Co.	Colaba Land	28,970	588	920
	Jehangir Wadia	10,740		270
	City of Bombay	30,340		760
	Great Eastern	46,470	1,059	1,500
	Sun	40,820		1,020
		157,340	1,647	4,470

Agents.	Mills.	Spind.	Looms.	I.H.P.
Sir Cowasji Jehangir & Co.	Coorla	30,880	557	960
	Jubilee	28,750		720
	Hope	28,800		720
		88,430	557	2,400
P. Hormarji & Sons	China	45,340		1,130
	Moon	23,400		590
		68,740		1,720
Naoroji Wadia & Sons	Spring	37,660	988	1,270
	Textile	53,070	1,701	1,900
		90,730	2,689	3,170
Currimbhoy Ibrahim & Co.	Crescent	44,580	1,106	1,480
	Currimbhoy	36,930		920
	Mahomedbhoy	46,470		1,160
	Pabani	55,020		1,380
	Fazulbhai	50,280	1,255	1,680
		233,280	2,361	6,620
Tulokchand & Shapurji	Gold Mohor	33.520		840
	Phœnix	48,370		1,210
		81,890		2,050
Bom. Petit & Sons	Emp. Edward	30,470	959	1 080
	Maneckji Petit	66,310	2,332	2,430
	Dinsha Petit	41,040	1,383	1,490
	Bomonji Petit	36,860	1,278	1,350
		174,680	5,952	6,350
Gordhandas Khatau	Bom. United	41,950	1,116	1,420
	Khatau	37,600	673	1,160
		79,550	1,789	2,580
Thakersey Moolji & Co.	Crown	20,870		520
	Hindustan	24,320	761	860
	Hongkong	28,710	572	910
	Indian	25,770	778	900
	Kaiser-i-Hind	26,240	764	910
	Western India	37,450	660	1,160
		163,360	3,535	5,260

Agents.	Mills.	Spind.	Looms.	I.H.P.
Finlay Muir & Co.	Finlay	30,100	616	960
	Swan	26,200	600	860
		56,300	1,216	1,820
David Sassoon & Co.	Sassoon	49,640	1,065	1,600
	Union	29,740		740
		79,380	1,065	2,340
C. N. Wadia	Century (1)	51,260	2,691	2,180
	Century (2)	38,260	351	1,070
		89,520	3,042	3,250
Sir Adamji	Adamjee	10,000	850	530
Tapidas Varajdas	Alliance	19,330	445	630
Khimji Assur	Assur	27,280		680
Chhoi Kuka	Coronation	46,610		1,170
Haji Usuf	Elphinstone	34,750	762	1,120
Sir Dinshaw Petit	Framji Petit	28,380	929	1,020
Shapurji Sorabji	Globe	29,030	414	860
Allana Munji	Indo China	34,130		850
Walji Shamji	Jam	28,060	750	950
Haji Bhai Lalji	Jewraj Baloo	34,410	565	1,050
Killick Nixon	Kohinoor	41,880	680	1,270
M. Bhagubhai	Lord Reay	28,420	455	860
Mathu. Goculdas	Madhavji	36,000	733	1,150
D. Jugjiwan	Matunga	4,180		100
Mor. Goculdas & Co.	Morarji	44,400	1,076	1,470
Shivlal Motilal	Motilal Pity	16,250		410
Haji Kasum	New Islam	15,700	317	300
Ab Rehamany	Noor Mill	25,210		630
K. Hathising	Pioneer		120	40
Run Narotamdas	Presidency	33,230		1,040
R. Hiramaneck & Co.	Queen	35,760		900
R. Jijibhoy & Co.	Ripon	43,550	337	1,200
Forbes, Forbes	Sarasvati	21,500		540
Tata Sons	Swadeshi	50,200	1,283	1,680
H. Mehta	Victoria	30,660		770

Cost of Steam Power.

The cost of steam power varies considerably even in mills of the same size, and under the same management. No reliable information has been published showing the friction losses in the engine and the rope-drive, nor are there any authentic figures of the actual cost of steam power, including all necessary charges. An average count mill with 40,000 spindles usually requires 1,000 I.H.P., but many mills have engines and boilers in excess of their existing requirements. Taking 1,000 I.H.P. for our calculations, the average consumption of coal may be taken at 10 to 11 tons per day, exclusive of steam for heating and sizing, or Rs. 55,000 per year of 3,600 working hours.

An average list of staff and wages is given below, but millowners have often to pay extra for consulting engineers and expert advice, and for over-time work during repairs, etc.

STAFF AND WAGES.

		Rs.
1	Engineer	300
1	Driver	50
4	Firemen	80
6	Coal carriers	72
2	Splicers	36
3	Oilers	45
2	Fitters	80
3	*Navganis*	51
3	Coolies	36
25	Monthly	750
		12
	Yearly	9,000

STORES AND REPAIRS.

	Rs.
Oil, Packing etc.	300
Ropes	120
Water	100
Repairs	230
Monthly	750
	12
Yearly	9,000

The capital cost of the steam plant may vary from Rs. 2,25,000 to 2,75,000 including land, building, tank, engines, boilers, economisers, etc., and the Directors have to provide for Depreciation and Interest on this. Taking the minimum cost of Rs. 2,25,000 and average Depreciation and Interest at 6 per cent., we have 13,500+ 13,500=Rs. 27,000 as additional charge on the steam plant.

The total annual cost will therefore be,—

		PER I.H.P.
Coal	55,000	55
Staff	9,000	9
Stores and Renewals	9,000	9
Interest	13,500	13·5
Depreciation	13,500	13·5
	Rs. 1,00,000	Rs. 100

Cost of Fuel in Bombay Mills.

The following are figures of the annual cost of coal as taken from the Balance Sheets. The mills are arranged in order of number of spindles and looms, the Horse-Power being reckoned as on page 53.

Spinning Mills.

Mill.	I. H. P.	Coal. Rs.
Jeh. Wadia	270	17,870
Moon	590	35 750
Assur	680	49,700
Jubilee	720	40,500
Union	740	45,520
New City	760	36,830
Connaught	820	42,200
Gold Mohur	840	51,190
Imperial	910	43,850
Jas. Greaves	950	45,730
Sun	1020	71,930
Kohinoor	1040	50,350
How. & Bullo.	1100	53,390
China	1130	57,510
Coronation	1170	55,130
Phœnix	1210	69,300
Pabani	1380	98,100
David (1 & 2)	1710	1,16,000
Empress (1 & 2)	1890	98,780
Currimbhoy	2080	1,65,570

Weaving Mills.

Mill.	I. H. P.	Coal. Rs.
Alliance	630	46,730
Jamshed	820	52,000
Hindustan	860	49,930
Indian	900	65,580
Hongkong	910	52,850
Colaba Land	920	71,470
Framji Petit	1020	71,290
Emp. Edward	1080	64,070
M. Dharamsey	1150	1,18,240
West India	1160	86,020
Bom. Petit	1350	1,26,300
Bom. United	1420	1,20,670
Standard	1470	1,18,130
Morarji	1470	1,18,860
Crescent	1480	1,28,960
Din. Petit	1490	1,07,480
Great Eastern	1500	98,640
Sassoon	1600	1,00,600
Fazulbhoi	1680	1,24,300
Mank. Petit	2430	2,21,500

Relative cost of Steam and Electricity.

Of the 83 cotton mills in the city, 26 will be driven by electric current from the works of the Tata Company and it will be interesting to compare the steam cost as shown on page 61 with the probable cost of electricity

The electric current will be provided at ·55 anna per unit including the supply and maintenance of the electrical plant required for driving the line shafts. We have therefore to reckon the aggregate number of units necessary to drive the line shafts which at present require 1,000 steam or Indicated Horse Power. Considerable difference of opinion exists as to the friction losses in the engine house and rope-alley in Indian mills for want of reliable data. In old engines, the total loss may vary from 25 to 30 per cent. and in a modern engine, with an efficient rope drive, it may be only 20 per cent. With the electric drive each line shaft will be separately driven by its own motor, which latter will register only the actual energy consumed by the machines when at work, thus saving power while the machines are temporarily stopped or while they run slower.

The advocates of electricity aver that a steam engine with a large fly wheel—the type most generally in use in Bombay—cannot possibly be as sensitive to the small but frequent fluctuations in the speed of machines as are the electric motors driving each line shaft separately. Therefore, taking the friction losses of the motors and other items into consideration, they calculate about 750 E. H. P. as the equivalent of 1000 I. H. P.

As one unit equals $1\frac{1}{3}$ E. H. P. we shall have $\frac{750\times3\times\cdot55\times3600}{4\times16}$ =Rs. 69,600 per year as the cost of electricity. To this must be added an annual charge of Rs. 1,600 for staff, oil, etc., or total,

Rs. 1,600+69,600 Rs. 71,200 for Electric Drive.

The comparative figures will therefore be—

Steam Rs. 1,00,000. Electricity Rs. 71,200,

or Rs. 28,800 in favour of the Electric Drive.

A distinct advantage of the electric drive is its steadiness of running, which gives increased production and improved quality of yarn and cloth. This increase varies from 5 per cent. to $7\frac{1}{2}$ per cent. according to the cotton, the average Indian staple benefitting particularly, as the breakages are reduced considerably by the steadier speed. Taking the minimum of 5 per cent. the increased production per day of average 20's count from the 40,000 spindles will be 1,000 lbs. or at average half anna per pound the gain will amount to Rs. 10,000 per year.

This will bring the approximate annual gain to 28,800+10,000=Rs. 38,800 for the electric drive; and even if we omit the interest charges of Rs. 13,500 from the steam cost on page 56, the difference will be Rs. 25,300 in favour of electricity.

The disposal of the engines and boilers has, however, to be considered. In the majority of cases these have been working for many years and their depreciated average value may be taken at Rs. 1,50,000 exclusive of the land, buildings, pumps and other appliances which can be utilized. Mill-owners have on previous occasions sold off old types of machinery at considerable loss to make room for improved and modern machinery such as the Ring Frames, Flat Cards, etc. The loss sustained by the removal of the steam plant can therefore be easily recouped by the annual saving of Rs. 25,300; and when the plant is disposed of the interest on it will not continue. At any rate the saving, even making allowance for the enthusiasm of the electrical engineer, is not impossible to obtain in the case of a large number of mills. It must also be noted that millowners will not have to find capital for the renewals of the engines, boilers and the plant generally; the saving in ten years under this head alone will make up for any temporary loss or inconvenience pointed out by those interested in the sale of steam plants.

The comparative position of the Bombay Millowner with and without electric drive may be summarised briefly as under :—

	STEAM.	ELECTRICITY.
Capital Cost Interest Depreciation Stores Renewals Repairs Land for Coal and Tank	Required	Not required
Breakdown	To be paid for	Not to be paid for
Extension of Plant	Time and Capital	Neither required
Staff	25 men	3 men
Expert Supervision	Required	Not required
Power Estimated	Difficult	Easy
Smoke Prosecution	Anxiety	None
Annual Expenditure	Varies	Fixed

The quality and quantity of production will also be favourably affected by the electric drive as will be seen from the opinions cited on page 60.

Increased Production and Better Quality.

In the controversy between the advocates of electricity and steam power, the comparative costs have often been discussed in wearying details, the steam engineer refusing to accept the claim for steadier drive by the electric current. In fact, in some instances the saving in power with electricity was said to be negligible, the benefit being the more efficient use of the energy transmitted and consequent greater production and better quality of material obtained. It has however been authoritatively stated that in a weaving shed, an increase of only two per cent. in production was sufficient to wipe out a good portion of the coal bill of the mill. This was also applicable to the spinning department, where the increase in production was even more noticeable when compared with the looms.

The results of careful tests in the various mills equipped by Messrs. Eckstein Heap & Co., of Manchester, enabled them to state with confidence that an increase of 10 per cent. production might be reckoned upon due to the change from mechanical to electric drive. Mr. C. D. Taile, Chief Engineer of the Lancashire Electric Power Co., stated that in the case of two similar weaving sheds which came under his notice, one driven by steam, and the other by electricity, not only was the output in the latter case increased, and the cost of upkeep reduced, but the cloth produced was of a better quality. The Directors of the Brunswick Mill stated that a larger production was obtained from the same machinery, the more regular turning giving an improved quality of yarn. Mr. Pearson, of Messrs. Pearson & Co., cotton spinners, Bury, mentioned that he was one of the largest users of power in the town. He had tried steam, gas, and electricity, and he preferred electricity as the steady driving gave a bigger output, with fewer breakages. Mr. W. B. Woodhouse, Resident Engineer of the Yorkshire Electric Power Company, Thornhill, said that the evidence of increased output from electrically driven machines was available from all parts of the world, and he noticed this himself in the case of a number of tests carried on by him in woollen mills. In one instance the output increased by 10 per cent. from the same machinery that was electrically driven and in another case the extra production balanced the whole of the cost of power.

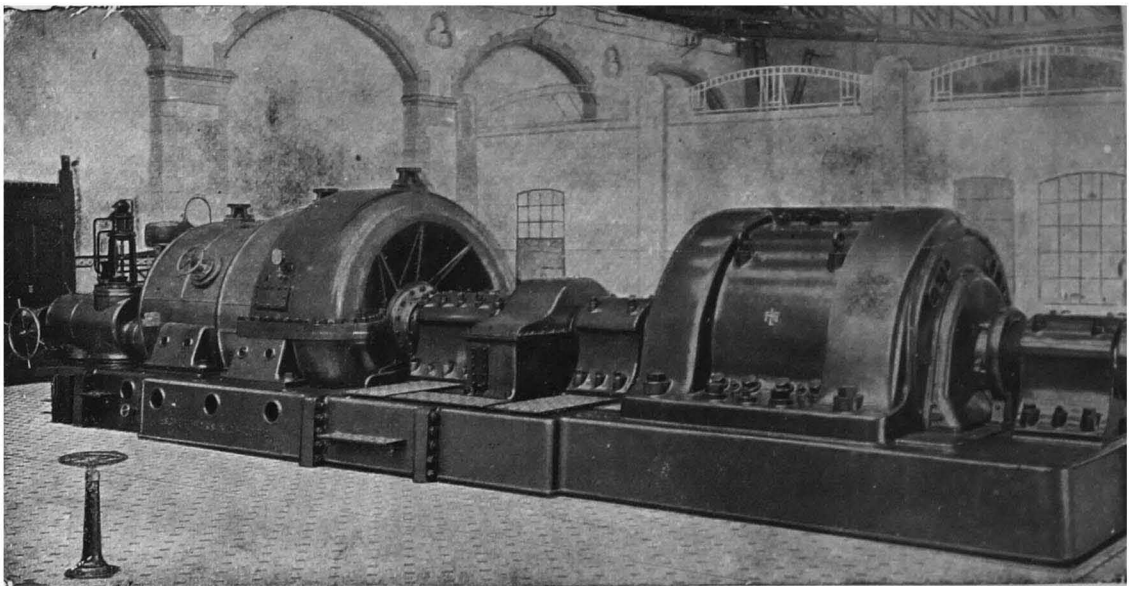
In several of the installations in Indian factories the increase in production and the improvement in quality have been distinctly noticeable. The Directors of the Finlay Mill in Bombay—the first complete spinning and weaving mill in India to be driven electrically—pointed to these benefits of electric drive in their earliest Reports, and they have been supported by other users of electric power in the country.

ELECTRIC DRIVE IN TEXTILE FACTORIES.

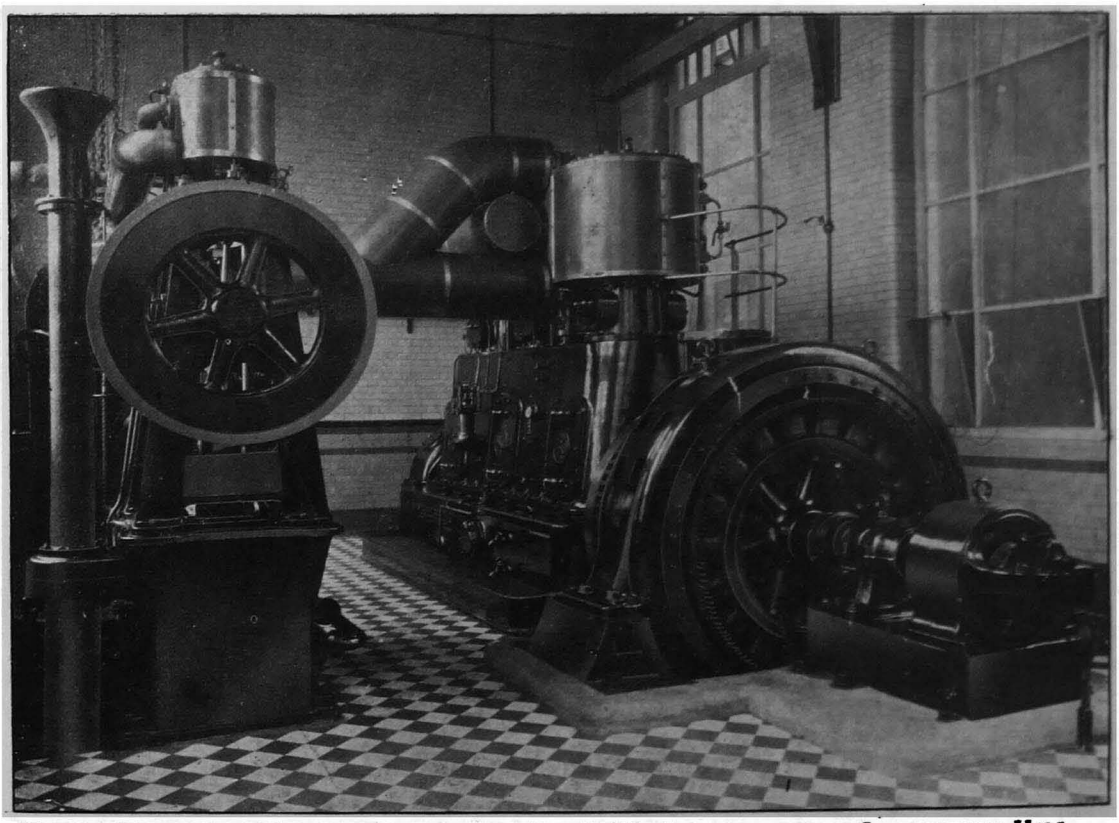
Installations in Lancashire.

The Indian mill owner is so accustomed to take his inspiration for reform from Lancashire spinners, that a reference to electrical installations in Manchester, Bolton and surrounding districts should prove instructive.

There is a well arranged plant at the Brunswick Mill owned by the Bannerman Mills Company, of which Sir Charles Wright Macara is managing director. This mill is being driven throughout by electricity from the mains of the Manchester Corporation, and contains both ring and mule spindles equal —on the Federation basis—to 100,000 mule spindles. The counts spun range from 36's to 72's and the different departments are driven by means of 37 three-phase induction motors aggregating a total of 1640 B.H.P., the installation being carried out under the supervision of Mr. S. M. Pearce, M.Inst.C.E., M.I.E.E. Other mills in Manchester driven electrically are the Butler Street Mills belonging to the Fine Spinners' Association and the Carruthers Street Mills of Messrs. Andrew & Bramhall, Limited. In Bolton, the public mains are supplying electric power for driving nearly 230,000 spindles and other auxiliary machinery. The Droylsden Mills, Farifield, owned by Messrs. Ashworth, Hadwen & Co., Ld., contains 89,000 spindles and 900 looms which are all electrically driven. Here the current is produced by means of a steam turbo-generator of 1000 B.H.P. capacity which distributes the energy to the various line shafts through 24 motors. It is interesting to note that the electrical plant in this case was put up in place of steam without stopping the mill or any department. The Premier Mill at Staylybridge, is electrically equipped throughout and is driven by means of three-phase current furnished direct from the Staylybridge, Hyde, Mossley and Dukinfield Joint Boards Main Generating Station. Mr. Robert Blackmore, A.M.I.E.E., was the Consulting Engineer, the plant being supplied by the British Westinghouse Company. Electric drive has also been adopted at Messrs. Lister & Co.'s mill, Bradford, at Sir Titus Salt's mill, Saltair, and at Messrs. Joshua Hoyle & Sons. Summerseat. The Acme Mill in Lancashire was one of the earliest to adopt this method of driving, the current being obtained from the mains of the Lancashire Electric Power Company. Other installations of note include the 1200 H.P. plant at the mills of Messrs. J. & M. S. Sharpe, Lowmoor, a 2000 H. P. plant at Messrs. Ashton Harrison & Company's factory at Staylybridge and the generating set of 1400 H.P. at the Albion Mills situated in the same district.



TURBO GENERATOR SET. THE TATA IRON AND STEEL WORKS, KALIMATI.



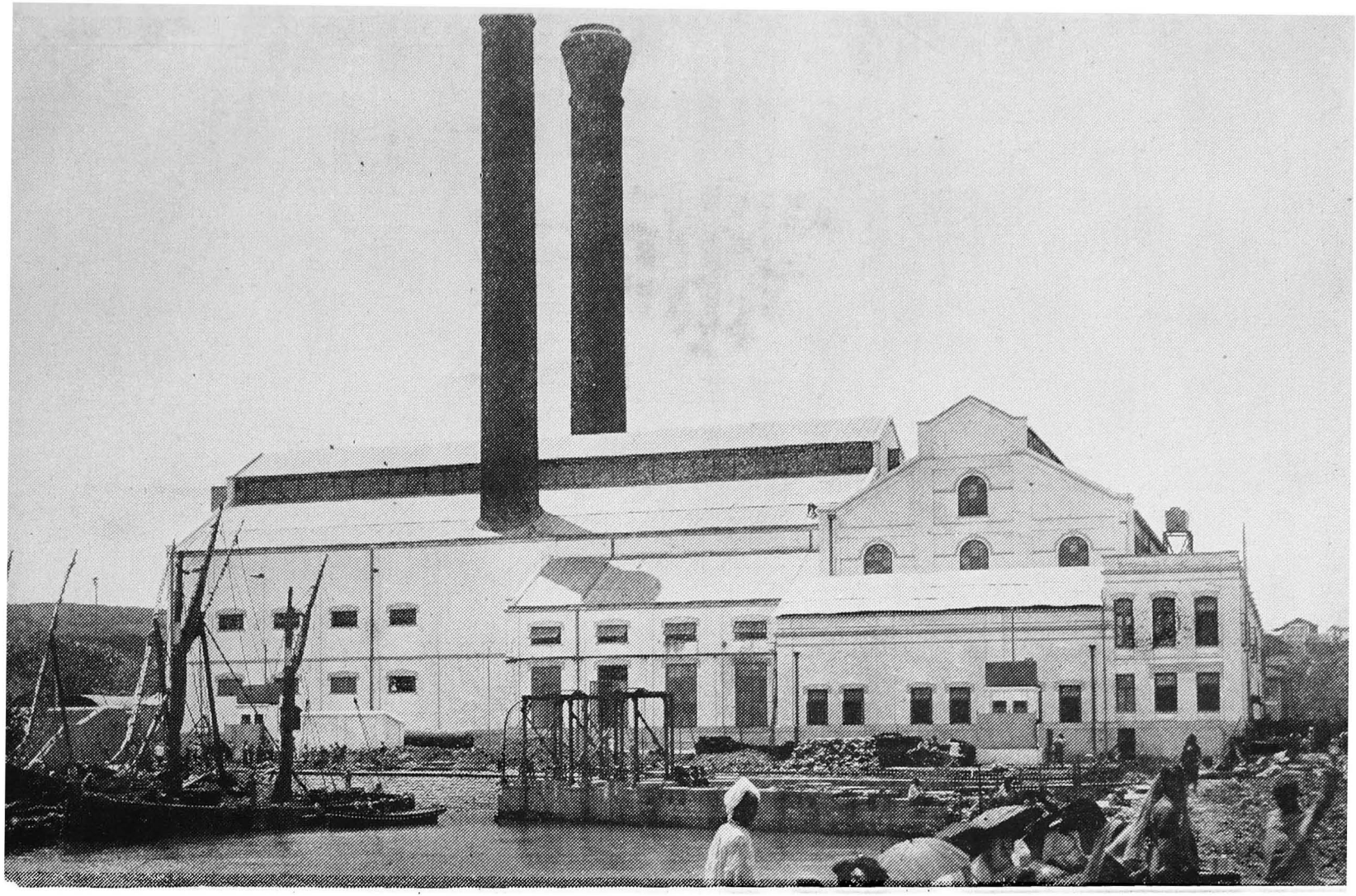
TRIPLE EXPANSION ENGINE: COUPLED TO 500 K. W. GENERATOR IN A LANCASHIRE MILL

Electrical Installations in India.

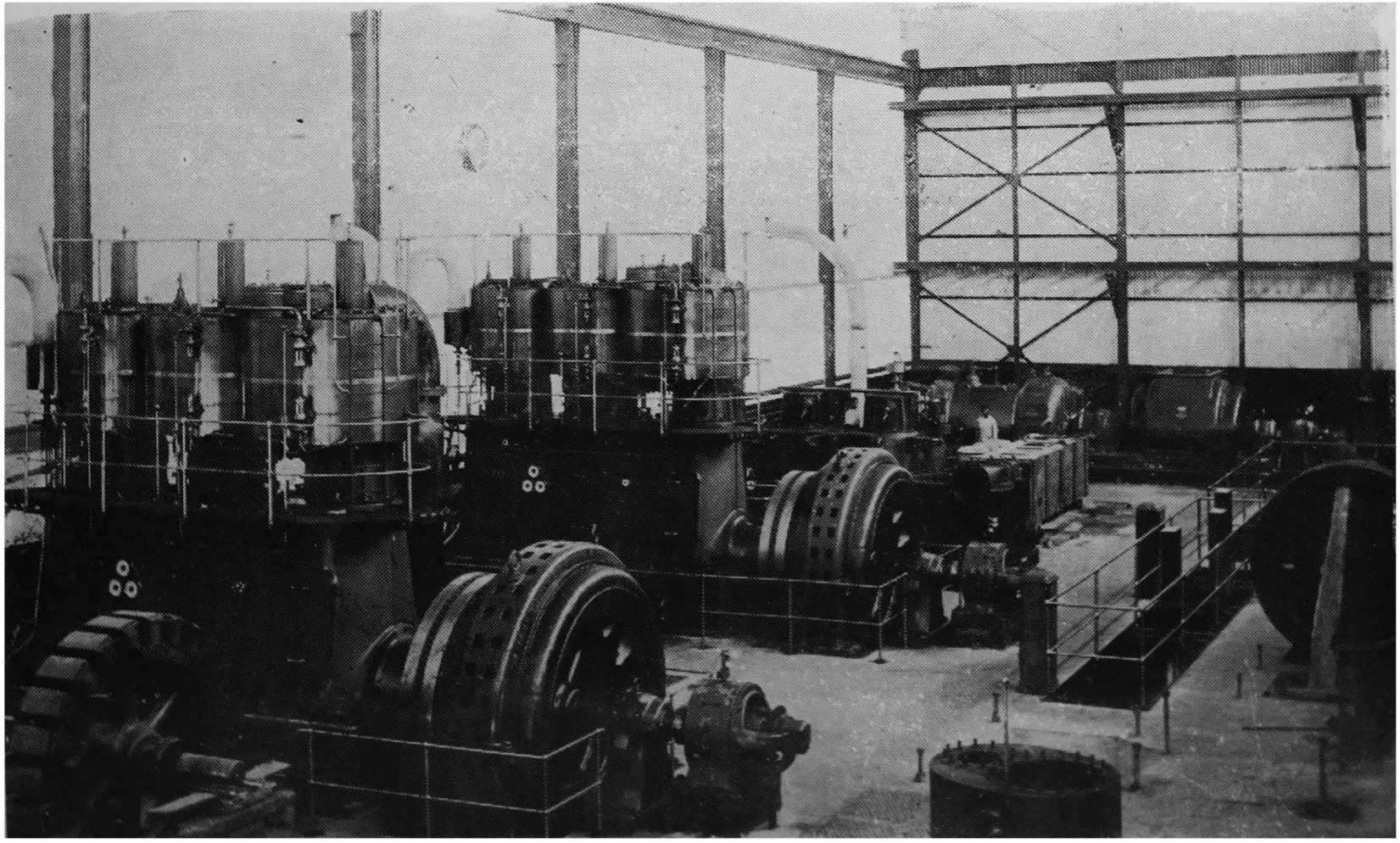
The larger electrical installations in India, include the plant at the Finlay Mills, Bombay, which was the first complete spinning and weaving mill in India to be driven throughout by electricity. The current is produced by a Westinghouse Generator and the line shafts are driven by separate motors by the same makers. The whole of the electrical equipment in this mill was supplied through Messrs. Bradbury, Brady & Company, Bombay. Messrs. Binny & Company of Madras have adopted electric drive for the Buckingham Mills under their management. The energy is generated on the mill premises, the entire weaving shed being driven electrically by six separate motors supplied by Messrs. Mather & Platt, Limited, Manchester. The E. D. Sassoon and the Jacob Sassoon mills in Bombay have electric generating plants of their own of 1000 and 800 horse-power capacity each, for driving the latest extensions in the spinning and weaving departments. The Jute factory of Messrs. Birkmyre Brothers, Calcutta, the Jute Press under the agency of Messrs. Andrew Yule and Company and the Ocean Jute Press of Mr. Harsookdas Doolychund at Chitapore, are all electrically equipped by Messrs. Speyer and Co., Calcutta. The large spinning and weaving extension at the Bombay United Mills is driven electrically, energy equal to nearly 600 I. H. P. being produced by a Westinghouse generator driven from the main engine. The Power House of the Rangoon Electric Tramway & Supply Company contains two 700 K. W. Curtis Turbines and a Belliss-Morcom high speed engine coupled direct to a 500 K. W. Generator by the British Thompson Houston Company; there is also a 500 K. W. motor generator set and a 1,500 K. W. vertical Curtis Turbine and a 300 K. W. motor generator set, with an additional 2,500 K. W. vertical turbine. The cables are supplied by the Callender's Cable Company, the British Insulated & Helsby Cable Company and partly by the General Electric Company. Mine owner in India have also taken advantage of electricity in the operations of the mines, the Nundydroog Mine, Mysore, having a 600 H. P. winding plant by Messrs. Siemens Bros. The State Railway at Gwalior has a complete electrical equipment by Messrs. Siemens for its workshops and power house, and the Budge Budge Jute Mills at Calcutta have a plant consisting of motors aggregating 450 horse power by the same makers. The drive at the Government Gun and Shell Factories at Cossipore and Ishapore, has been converted from steam to electric. Two generator sets are supplied by Messrs. Crompton & Company, of Chelmsford, each 200 K. W. capacity and fitted to Belliss-Morcom high-speed engines. The General Electric Company has supplied two extra generators of 50 K. W. each, while nearly 200 motors varying from 10 to 120 H. P. each, have been installed by the Lancashire Dynamo & Motor Company, of Manchester. The Hindusthan Cotton Mills Company, Ltd., has been registered in Calcutta, for the manufacture of fancy

goods, longcloths, etc., it being arranged that the mill shall be electrically driven by energy from the works of the Calcutta Electric Corporation. The Shri Baldeo Cotton Mills at Hathras produces its own electricity by means of a steam turbo generator which drives the line shafts of the preparatory machinery by motors, while the ring frames are driven in pairs by direct coupled motors. The Caxton Printing Works of Messrs. G. Claridge & Co., Bombay, are driven by electricity since their location in the extensive premises built by them in 1910. The large machines are driven individually by motors averaging four horse power, group driving being adopted for ths smaller machines. The Caxton Press is the first printing establishment in India to be laid out completely for electric power and lighting, the plant being supplied by Messrs. Javeri and Co., Bombay. The Brush Company's generating plant for the Bombay Tramway & Electric Supply Company consists of ten sets of generators aggregating an initial capacity of 8,800 kilowatts ; these include four sets of turbo-generators, total 4,500 kilowatts and six sets of reciprocating engines and generators giving 4,300 kilowatts ; provision has also been made for three 700 kilowatt exhaust steam turbo generators, for use in connection with the three 1,000 kilowatt reciprocating sets. The whole of the plant produces 3-phase electric energy at a pressure of 5,500 volts between phases, and supplies current within Bombay city for light, traction and power purposes. The Burmah Oil Mill at Budge Budge has been fitted with an electrical generating plant by Messrs. Speyer & Co., agents for the A. E. G. Lahmeyer Company. The same firm has equipped Messrs. Andrew Yule's Flour mill in Calcutta for electric drive, as also the Suraj Jute Press, the Sun Press and the Central Jute Press ; the Ocean Press and the Victoria Press have also been converted from steam to electric drive by the same Company, together with the Monarch Flour Mill and the Fort William Flour Mill in the same district. Messrs. Siemens Bros. are putting up a central power station for the state of Bikanir and another for Gwalior, the current in both cases being produced by steam power and utilised for lighting and power purposes. A complete electrical plant for power and lighting purposes has also been installed by Messrs. Siemens at the mills of the Indian Bleaching Dyeing & Printing Works, Bombay, and large sections of the India Jute mill at Calcutta and the Oil and Flour Mills at Bikanir, are being electrically driven with plants by the same makers.

The old Swadeshi Mills at Nagpore, which Messrs. Tata Sons & Company recently purchased from Messrs. Bomonji Petit & Sons, is being rebuilt and furnished with new machinery including 30,000 ring spindles and 500 looms. The mill will be driven throughout by electricity generated on the premises, the power plant consisting of Daniel Adamson's steam turbines, coupled to a Siemens' generator, the motors being supplied by Messrs.



THE POWER STATION OF THE BOMBAY TRAMWAY AND ELECTRIC SUPPLY COMPANY, LIMITED, BOMBAY.



THE LARGEST ELECTRICAL POWER STATION IN INDIA.
THE GENERATING PLANT OF THE BOMBAY TRAMWAY AND ELECTRIC SUPPLY COMPANY LIMITED, BOMBAY.

Mather & Platt, Limited. The equipment by Messrs. Siemens Bros. will consist of a 900 k.w. three-phase alternator running at a speed of 2,400 R.P.M. at a frequency of 40 cycles. There is a Crompton dynamo and motor plant of 400 K. W. capacity and 440 volts for driving the line shafts of Sirdar Sir Chinubhai Madhawlal's mill at Ahmedabad. The Madras Portland Cement Works are driven electrically by Siemens Brothers' motors aggregating 600 horsepower. The whole of the New Kaleewarar Cotton Mill at Coimbatore, has been fitted with a large generating plant by the Westinghouse Electric Company, the ginning factory of the Akola and Mid Indian Spinning and Weaving Company being provided with electric plant by the same makers. The Tata Iron and Steel Works at Kalimati have been fitted with a large electrical plant manufactured by the A. E. G. Lahmeyer Company and supplied through Messrs. Speyer & Company, of Calcutta. There are three steam turbines by Messrs. Escher Wyss & Company, of Zurich, direct coupled to three-phase generators, each having a normal output of 1250 K. V. A.; also three turbo blowers direct coupled to steam turbines which have a maximum output of 2,240 H. P. at 2,500 r. p. m.

His Majesty's Mint at Calcutta is being electrically driven throughout since 1908, with three sets of direct current spring wound generators of 270 K. W. each and another of 50 K. W., all being driven by Belliss-Morcom high speed engines supplied with steam from Babcock & Wilcox water-tube boilers. The mint machinery is driven by separate motors supplied by the General Electric Company. It is interesting to note that the electrical installation at this mint has taken the place of seven steam engines of the oldest type as made by James Watt & Company, in 1829.

There is an electric plant at Messrs. Tata's Swadeshi Mills, at Coorla, near Bombay, for driving the new bleach house and 20,000 ring spindles. The motive power is supplied by a Belliss-Morcom engine coupled to a Westinghouse generator, the current being distributed by means of three-phase motors aggregating 400 H. P. The power station of the North-Western Railway at Lahore contains an up-to-date plant, with two 125 and two 250 K. W. T. sets with the Lancashire Dynamo Company's generators and four 400 K. W. T. Browett-Lindlet engines with Westinghouse generator.

Among other installations of note are those at Cawnpore, Calcutta and Madras for the supply of electric current for light, power and traction purposes, the electric lighting plant at Calcutta being the first of its kind of any importance in the country; these have been installed by Messrs. Crompton & Company, Limited, Chelmsford.

Useful Notes and Information.

Definitions of Electrical Terms.

Ampere-hour Meter—An instrument giving the total time integral of the amperes.

Auto-balancer.—An auto-transformer for equalising the load or voltage when a three, or more, wire circuit is derived from a two-wire circuit.

Auto-transformer.—A transformer in which a part of the primary winding is used as the secondary winding, or conversely.

NOTE.—These are frequently used for starting large three-phase motors which have squirrel-cage rotors. (See below for *Induction Starter.*)

Block or Bulk Supply Rate.—Method of charging for electric service at different successive rates per kilowatt-hour consumed, each successive rate applying only to a corresponding successive block or quantity of the total current purchased during the period covered. As an example, during each month 10kw.-hours or less are charged at $7\frac{1}{2}d.$ per kilowatt-hour; the next 10kw.-hours over the first are charged for at $6d.$ per kilowatt-hour; all current in excess of the foregoing 20kw.-hours is charged for at $5d.$ per kilowatt-hour.

Choke Soil.—A reactance used in connection with lightning arresters, and placed in series with the line to be protected.

Capacity Factor.—Ratio of the station output in kilowatt-hours to the maximum capacity of the station in kilowatts.

Compensated Alternator.—A separately excited alternator, which automatically compensates for the drop in voltage in its armature, or in its armature or the line, by sending around its field a rectified portion of the main current, or of the current derived from a series transformer in the main circuit.

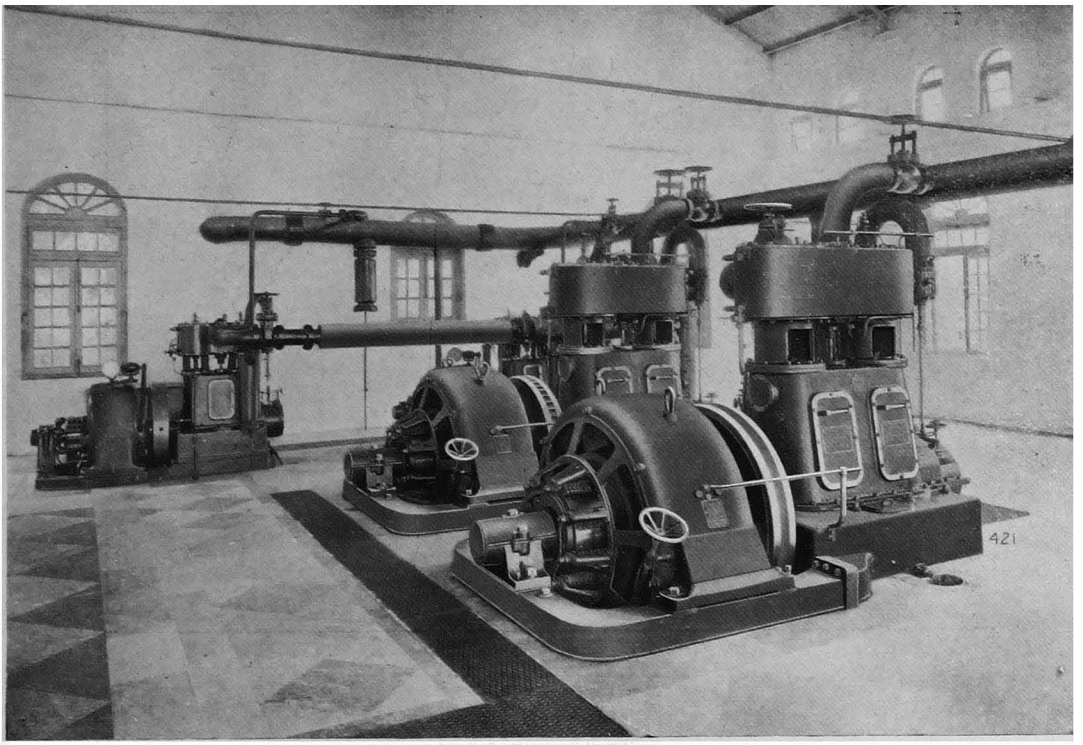
NOTE.—This is much the same thing as the compounding of a dynamo by series coils.

Convertor.—A dynamo-electric machine having one armature and one field for converting alternating current to direct current, or direct current to alternating current. The term to be preceded by the words "alternating current-direct current" (A.C., D.C.) or "direct current" (D.C.)

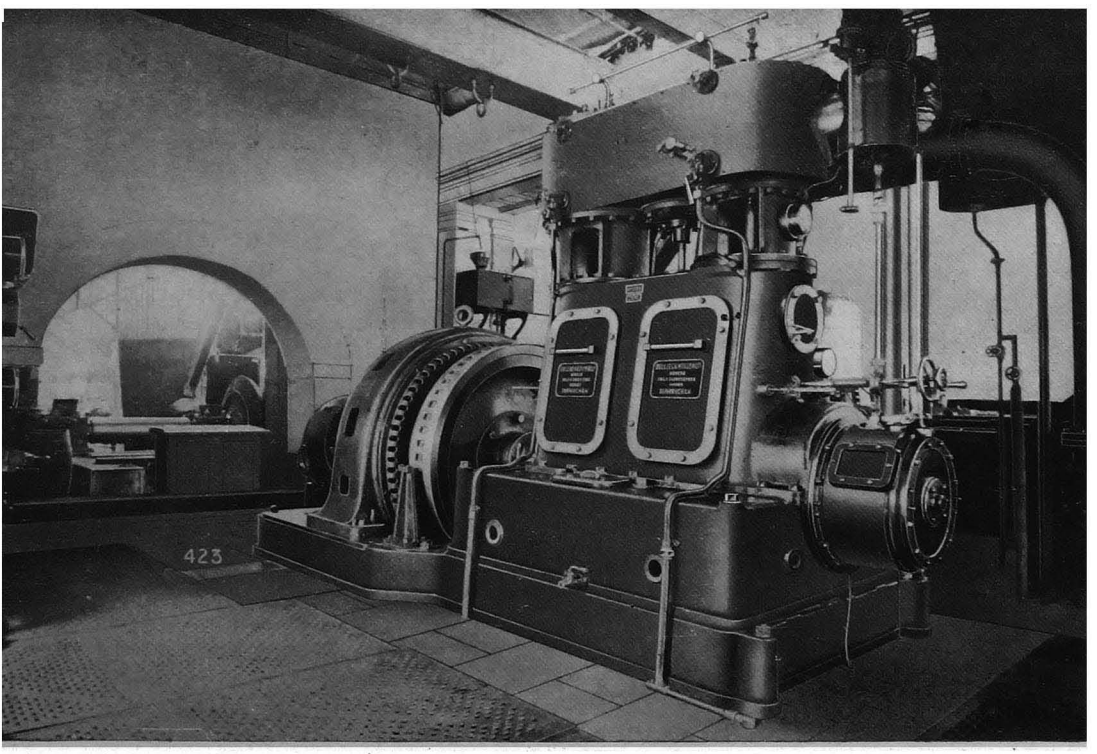
Constant.—(1) of an electrical instrument, is that quantity which used as a factor with indications of instruments gives results in the desired unit; (2) of a watt-hour meter, is 3600 × watt-hours passing through the circuit during one revolution of the meter disc.

Corrective Motor.—A synchronous motor, running either idle or under load, whose field charge may be varied so as to modify the power factor of the circuit to which it is connected, or through such modification also to influence the voltage of the circuit (this term is proposed instead of the term "rotating condenser.")

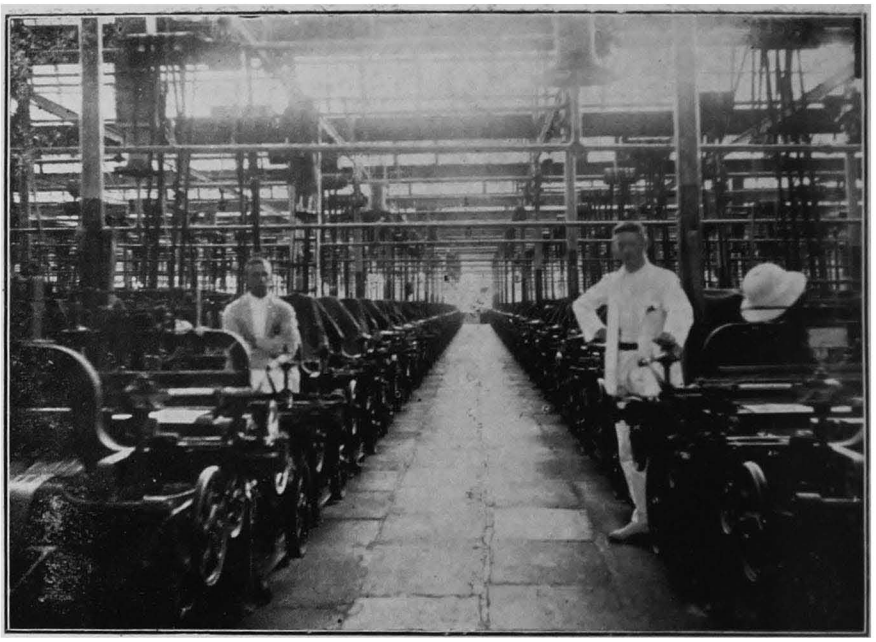
* The above list is used by the National Electric Light Association of the United States.



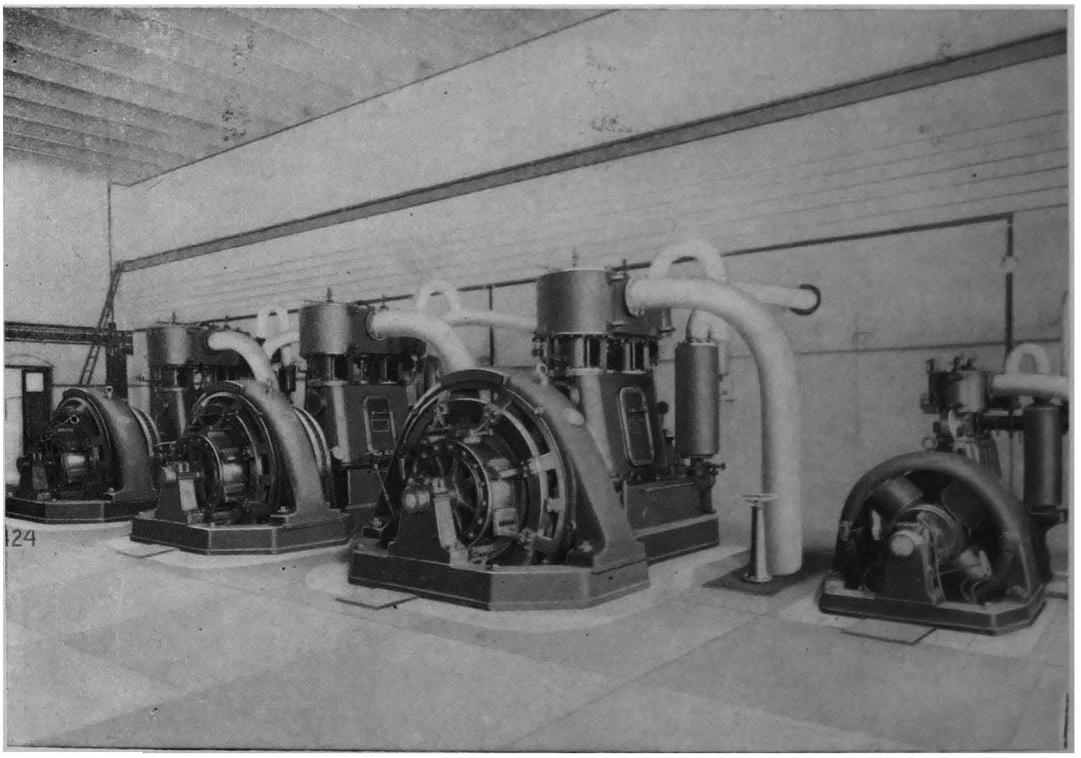
ELECTRICAL GENERATING SET. GOVERNMENT SHELL FACTORY COSSIPORE.



ELECTRICAL GENERATING SET. SWADESHI MILL, KURLA, BOMBAY.



ELECTRICALLY DRIVEN LOOM SHED. BUCKINGHAM MILLS, MADRAS.



ELECTRICAL GENERATING SETS. HIS MAJESTY'S MINT, CALCUTTA.

Demand Factor.—Unless otherwise specified, demand factor shall be the maximum connected kilowatts of capacity divided into the actual kilowatts of demand, and expressed in terms of per cent.

Demand Rate.—The price, or part of the price, of power charged for the demand as distinguished from the price paid for the kilowatt-hour consumption.

Discriminating Rate.—A rate which does not give the same price for two or more customers, when all other conditions are equal.

Differential Rate.—A rate consisting of two opposed factors—one tending to give a high rate, and the other tending to give a low rate.

Dispersion Factor.—The factor applied to light intensity after dispersion, which gives the intensity if the dispersion agents are removed.

Diversity Factor.—Diversity factor shall be used to express the relation between the simultaneous demand of all individual customers and the sum of the maximum demand made by these customers; the sum of the maximum demand of the customers, no matter at what time they occurred, divided into the simultaneous greatest maximum demand when expressed in per cent., will give the diversity factor.

Note.—It is a good thing not to have all the peak loads coming on the generating plant at the same time.

Effective Demand.—The demand taken at the time of the system's greatest maximum.

Effective Load Factor.—The meaning suggested is the main load of a part of a system determined by the load at the time of the system's maximum. This value would be infinity if the services were off at the time of the system's maximum, as in the case of non-peak service. The term "effective demand" is suggested as a substitute.

Equalising Rings.—Rings connected to equipotential points of multiple-wound armature to equalise the voltage between the brushes.

(These rings are generally only found on large multipolar dynamos.)

Feeder.—An electric circuit, used to supply power to a station or service, as distinguished from circuits confined to a single station or used for other purposes than supplying power.

Flaming Arc Lamps.—An arc lamp using carbon electrodes impregnated with some light-giving material.

Flat Rate.—Method of charging for electric service only a fixed sum per month, or per annum, for a specified service, as supplying a certain number of outlets, or up to a certain maximum demand without reference to the quantity of electricity actually consumed.

Frequency Changer.—A piece of apparatus for changing from one frequency to another, consisting of a motor driving either an ordinary alternating-current generator or a machine constructed like an induction motor. In the former case

the term is to be preceded by the words "motor-generator," and in the latter case by the word "induction."

Fuse—Electric.—A conductor designed to melt or fuse at a certain value of current and time, and by so doing to rupture the circuit.

NOTE —**Very frequently called a *cut-out.***

Gem Lamp.—An incandescent lamp using a carbon filament, which has a positive temperature coefficient of resistance.

High Frequency.—A frequency so high that Ohm's law does not apply even approximately.

Hydro-electric System.—An electric system with generator driven by water power.

Induction Generator.—A machine similar to the induction motor, but driven as an alternating-current generator.

Induction Starter.—A device used in starting induction motors, converters, etc. (when they are started by voltage control), consisting of an auto-transformer in connection with a suitable switching device.

Induction Alternator.—An alternating-current generator in whose armature windings the main magnetic flux pulsates but never reverses.

Instantaneous Peak.—The highest value reached by the quantity under consideration as measured by some device which indicates the actual value of the quantity at every moment.

Insulator—Electric.—A body or substance which offers such resistance to the passage of electric current that it is used to prevent the passage of current.

Intensified Arc Lamp.—A term used for an arc lamp, with one of the carbons of small diameter to give a large current density per unit of arc, on which the arc plays to thereby intensify the light.

Leakage Reactance.—That portion of the reactance of any piece of induction apparatus which is due to stray field.

Load Factor.—The fraction, expressed in per cent., obtained by dividing the average load over any given period of time by the highest average load for any one minute during the same period of time.

Load-factor Rate.—A rate based on load factor.

Low Tension.—A relative term used to designate a winding or conductor of less voltage than that with which it is related or compared.

(Anything below, say, 120 volts might be considered as *low tension.*)

Maximum Demand.—The maximum demand may be stated in kilowatts, horse-power, 16 candle-power equivalents, or any other term specified, but preferably should be stated in terms which leave no opportunity for error, and wherever possible should be stated in kilowatts. Unless specified it shall always

mean absolutely the greatest actual maximum demand. If the greatest actual maximum demand is not intended, but it is intended to express the greatest maximum demand for a given day or a given minute, then it shall be so stated.

Maximum Instantaneous Demand.—The highest load reached as measured by indicating or recording instruments at any moment.

Maximum Simultaneous Demand.—A maximum simultaneous demand shall be used to express the greatest absolute aggregate sum of certain individual demands, such as *(a)* customers; *(b)* class of customers; *(c)* class of current; and all rules made to define maximum demand shall apply to simultaneous maximum demand.

Momentary Peak.—The highest average load carried during any fifteen seconds of a specified period.

(In the case of momentary peak-load-factor peak-loads the terms may be preceded by the qualifying terms "hourly," "daily," "monthly," "yearly," etc.)

Moonlight Schedule.—A Schedule of burning hours for lamps which are not lighted when the moon shines.

Non-peak or Off-peak Rate.—A rate conditioned on the non-use of service during specified hours of central-station peak load.

Operating Time Factor.—The ratio of the number of hours of operation to the number of hours in the interval considered. This can best be fixed by an example: There are 8760 hours in the year. If a given shop operates 10 hours a day, for 300 days in a year, it may be said to have an operating factor of 34.11 per cent.

Operating Time Load Factor.—The load factor considered only during the time of operation. This can also best be defined by example, and would be used to express the load factor for the running time of a shop, that is, if a shop operates 10 hours a day and 300 days in a year, the divisor would be 3000 hours, or such other number of hours as represented the time of running instead of the usual divisior of 8760 hours in the year.

Peak.—The highest average load carried during one minute of any specified period.

Peak Load.—The highest average load carried during one hour of any specified period.

Power-factor Indicator.—A device to indicate the power factor of an electric current.

Primary.—That winding of an induction motor or of a transformer which directly receives power. The term is to be preceded, in the case of transformers, by the words "high voltage" or "low voltage," in the case of induction motors by "rotating" or "stationary."

NOTE.—A transformer may step down the voltage or step it up. (See *Secondary* below.)

Quantity Increment Rate.—See *Block Rate.*

Quarter-phase.—A term implying the supplying of power through two circuits. The vector angle of this voltage is 90 degrees. This term is recommended instead of the term "two-phase."

Reactance Soil.—A coil for producing difference of phase or for eliminating current.

Recording Ammeter, Recording Voltmeter, Recording Wattmeter.—Instruments which make upon a chart a continuous record of the value of quantities they measure.

Regenerative Arc Lamp.—A flaming enclosed arc lamp in which the products of combustion are circulating and brought rapidly in contact with the arc. The objects accomplished thereby are: (1) to conserve the heat; (2) to condense and deposit the solid products of combustion where they will not obstruct the light; and (3) to exclude the oxygen and utilise rapidly the chemicals in the circulating gases.

Reverse-current Relay.—A relay used on a direct-current circuit, which operates when the current flows in the direction opposite to the normal direction.

Reverse-power Relay.—A relay which operates when the power in the circuit flows in the direction opposite to the normal direction.

Rotor.—The rotating member, whether primary or secondary, of any alternating-current machine.

Secondary.—That portion of an induction motor or of a transformer which receives power by induction. The term is to be preceded by the same words as in the case of "primary."

Simultaneous Demand.—The sum of the demands of a number of services occurring at the same time.

Simultaneous Demand Factor.—The ratio of the simultaneous demand divided by the connected load.

Static Converter.—A term not recommended for a transformer.

Stator.—The stationary member, whether primary or secondary, of any alternating-current machine.

Step Rate.—Method of charging for electric service at definite successive rates per killowatt-hour consumed, each rate applying to the entire quantity purchased during the period. As, for example, during each month 10kw.-hours or less at 7½*d.* per kilowatt-hour. If over 10kw.-hours and less than 20kw.-hours are used, all are charged for at 6*d.* per kilowatt-hour. If 20 or more kilowatt-hours are registered during the month, all are charged for at 5*d.* per kilowatt-hour.

Strain Insulator.—An insulator used for the double purpose of taking the mechanical strain at a bend or at the end of a conductor, and also insulating the same electrically.

Synchronism Indicator.—A phase indicator. A device for indicating the phase relation or the condition of synchronism between two or more periodic quantities.

Synchroscope.—A synchronising device which, in addition to indicating synchronism, shows whether the machine is synchronised fast or slow.

(The words static transformer and rotating transformer are sometimes used.)

Transformer.—A stationary piece of apparatus for transforming by electro-magnetic induction, power from one circuit to another, or for changing, through such transformation, the values of the electromotive force.

Turbo-generator.—A steam turbine coupled to an electrical generator.

(Turbo-alternator and tur-dynamo are terms in common use.)

Voltage Regulator.—A device for regulating or varying the voltage of a circuit. When it consists of a transformer (whose primary is in shunt to a circuit, and whose secondary is in series with the circuit) whose ratio may be varied, the term is to be preceded by the term "induction" or "contact," according as the voltage is varied by changing the amount of magnetic flux between the primary and the secondary, or by changing the number of turns in the secondary in series with the circuit.

Voltmeter Compensator.—A device used in connection with a voltmeter to make it read low by the amount of the line drop, and thus cause it to indicate the voltage delivered at the end of the line or at any other predetermined point of the line.

Watt-hour Meter.—An instrument giving the total time integral of the watts.

Wattless Component Indicator.—A device for measuring the products of voltage of a circuit, and the component of current at 900 with the voltage. This product is the heating effect in excess of the heating that would be given by a circuit of the same voltage and power at 100 per cent. power factor.

Electrical Terms; Standard Rules.

Converters.—A converter is a machine employing mechanical rotation in changing electrical energy from one form into another. A converter may belong to either of several types as follows:—

(*a*) A direct current converter converts from a direct current to a direct current. (*b*) A synchronous converter (commonly called a rotary converter) converts from an alternating to a direct current, or *vice versa*. (*c*) A motor convertor is a combination of an induction motor with a synchronous converter, the secondary of the former feeding the armature of the latter with current at some frequency other than the impressed frequency—*i.e.*, it is a synchronous converter concatenated with an induction motor. (*d*) A frequency converter converts from an alternating-current system of one frequency to an alternating-current system of another frequency, with or without a change in the number of phases or in voltages. (*e*) A rotary phase converter converts from an alternating-current system of one or more phases to an alternating-current system of a different number of phases, but of the same frequency.

Currents.—A direct current is a unidirectional current. A continuous current is a steady or non-pulsating direct current. A pulsating current is a current equivalent to the super-position of an alternating current upon a continuous current. An alternating current is a current which, when plotted, consists of half waves of equal area in successively opposite directions from the zero line. An oscillating current is a current alternating in direction and of decreasing amplitude.

Loads, Power, and Load Factors.—The load factor of a machine, plant, or system is the ratio of the average power to the maximum power during a certain period of time. The average power is taken over a certain interval of time, such as a day or a year, and the maximum is taken over a short interval of the maximum load within that interval. In each case the interval of maximum load should be definitely specified. The proper interval is usually dependent upon local conditions and upon the purpose for which the load factor is to be determined.

A non-inductive load is a load in which the current is in phase with the voltage across the load. An inductive load is a load in which the current lags behind the voltage across the load. A load in which the current leads the voltage across the load is sometimes called an anti-inductive load.

The power factor in alternating-current circuits or apparatus is the ratio of the electric power in watts to the apparent power in volt-amperes. It may be expressed as follows:—

$$\frac{\text{True power}}{\text{Apparent power}} = \frac{\text{watts}}{\text{volt amperes}} = \frac{\text{energy current}}{\text{total current}} = \frac{\text{energy voltage}}{\text{total voltage}}$$

The reactive factor is the ratio of the wattless volt-amperes—*i.e.*, the product of the wattless component of current by voltage, or wattless component of voltage by current—to the total amperes. It may be expressed as follows:—

$$\frac{\text{Wattless volt amperes}}{\text{Total volt-amperes}} = \frac{\text{wattless current}}{\text{total current}}$$

$$\frac{\text{wattless voltage}}{\text{total voltage}}.$$

Power factor and reactive factor are related as follows: If p=power factor, and q=reactive factor; then with sine waves or voltage and current,—

$$p^2 + q^2 = 1.$$

With distorted waves of voltage and current,—

$$p^2 + q^2 = \text{or} < 1.$$

Motors—Speed Classification.—Motors may for convenience be classified with reference to their speed characteristics as follows:—

(*a*) Constant-speed motors, in which the speed is either constant or does not materially vary, such as synchronous motors, induction motors with small slip, and ordinary direct-current shunt motors. (*b*) The multi-speed motors (two-speed, three-speed, etc.), which can be operated at any one of several distinct speeds, these speeds being practically independent of the load, such as motors with two armature windings. (*c*) Adjustable-speed motors, in which the speeds can be varied gradually over a considerable range, but when once adjusted, remains practically unaffected by the load, such as shunt motors designed for a considerable range of field variation. (*d*) Varying speed motors, or motors in which the speed varies with the load, decreasing when the load increases, such as series motors.

Potential Regulators.—In potential regulators a coil is in shunt and a coil is in series with the circuit, so arranged that the ratio of transformation between them is variable at will. They are of the following three classes:—

(*a*) Compensator potential regulators, in which a number of turns of one of the coils are adjustable. (*b*) Induction potential regulators, in which the relative positions of the primary and secondary coils are adjustable. (*c*) Magneto potential regulators, in which the direction of the magnetic flux with respect of the coils is adjustable. (*d*) Reactors, or reactance coils, formerly called choking coils, are a form of stationary induction apparatus used to produce reactance or phase displacement.

Rotating Machines.—A generator transforms mechanical power into electrical power. A direct-current generator produces a direct current that may or may not be continuous. An alternator or alternating-current generator produces alternating

current, either single-phase or polyphase. A polyphase generator produces currents differing symmetrically in phase, such as two-phase currents, in which the terminal voltages on the two circuits differ in phase by 90 degrees; or three-phase currents in which the terminal voltages on the three circuits differ in phase by 120 degrees. A double-current generator produces both direct and alternating currents. A motor transforms electrical into mechanical power. A booster is a machine inserted in series in a circuit to change its voltage. It may be driven by an electric motor (in which case it is termed a motor booster) or otherwise. A motor generator is a transforming device consisting of a motor mechanically connected to one or more generators. A dynamotor is a transforming device combining both motor and generator action in one magnetic field, with two armatures, having two separate windings and independent commutators.

Stationary Induction Apparatus.—Stationary induction apparatus change electric energy to electric energy through the medium of magnetic energy. They comprise several forms, distinguished as follows:—

(*a*) In transformers the primary and secondary windings are insulated from one another. (*b*) In auto-transformers, also called compensators, a part of the primary winding is used as a secondary winding, or conversely.

* *N. B.*—**The above are Extracts from the Rules of the American Institute of Electrical Engineers.**

The Indian Electricity Act, 1910.

The new Electricity Act for India (Act IX of 1910) came into force on January 1st, 1911, and embodies several improvements on the previous enactment. The following terms are selected from the Rules under the Act, and for a clear conception of its requirements the reader in referred to Mr. J. W. Mears' excellent work entitled "The Law Relating to Electrical Energy in India."

Definitions of Electrical Terms.

"**Correct**" a meter, maximum demand indicator or other apparatus shall be deemed to be "correct," within the meaning of section 26 of the Act, when its limit of error as certified by an Electric Inspector does not exceed 3 per cent. above or below absolute accuracy at all loads in excess of one-tenth of full load;

"**cut-out**" means any appliance for automatically interrupting the transmission of energy through any conductor when the current rises above a predetermined amount;

"**pressure**" means the difference of electric potential measured in volts between any two conductors, or between any part of either conductor and the earth, and is said to be—

(i) "low" where, under ordinary working conditions, it cannot exceed 250 volts by an amount greater than four per cent. of the normal pressure;

(ii) "medium" where, under ordinary working conditions, it may exceed 250 volts, but cannot exceed 650 volts by an amount greater than 12½ per cent. of the normal pressure, and

(iii) "high" where the conditions are such that it may exceed 650 volts;

"**ampere**" means a unit of electric current, and is the unvarying electric current which, when passed through a solution of nitrate of silver in water, (in accordance with the Specification * given below) deposits silver at the rate of 0·001118 of a gramme per second:

such aforesaid unit is represented by the current which is passing in and through the coils of wire forming part of the instrument marked "Government of India Ampere Standard verified" when the suspended coil in its sighted position is exactly balanced by the force exerted by gravity in Calcutta on the inidio-platinum weight marked "A" forming part of the said instrument;

"**ohm**" means a unit of electric resistance, and is the resistance offered to an unvarying electric current by a column of mercury at the temperature of melting ice 14·4521 grammes in mass of a constant cross sectional area and of a length of 106·3 centimetres:

such aforesaid unit is represented by the resistance between the terminals of the instrument marked "Government of India Ohm Standard verified" to the passage of an unvarying electric current when the coil of wire forming part of the aforesaid instrument and connected to the aforesaid terminals is in all parts at a temperature of 30°C.;

"**volt**" means a unit of electro-motive force, and is the electric pressure which, when steadily applied to a conductor whose resistance is one ohm, will produce a current of one ampere; and

"**watt**" means a unit of power, and is the energy expended per second by an unvarying electric current of one ampere under an electric pressure of one volt.

* The electrolyte shall consist of a solution of from 15 to 20 parts by weight of silver nitrate in 100 parts of distilled water. The solution must only be used once, and only for so long that not more than 30 per cent of the silver in the solution is deposited. The anode shall be of silver, and the kathode of platinum. The current density at the anode shall not exceed 1,5 ampere per square centimetre and at the kathode 1,50 ampere per square centimetre. Not less than 100 cubic centimetres of electrolyte shall be used in a voltameter. Care must be taken that no particles which may become mechanically detached from the anode shall reach the kathode. Before weighing, any traces of solution adhering to the kathode must be removed, and the kathope dried.

Electrical Work in India: Directory of Engineers.

(Corrections and additions for this List will be thankfully received.)

Akey, M. A.	Tata Hyd. Elec. Co.	Bombay
Allen, H. P.	Calcutta Tram Co.	Calcutta
Ash, H. D. A.M.I.E.E.,	Turner, Hoare & Co.	Bombay
Baker, J. C.	Elec. Sup. Tram Co.	Bombay
Baker, P. M.	V. J. T. Institute	Bombay
Baldwin, L. C. A.M.I.E.E.,	Apollo Street	Bombay
Barnard, A. G.	Greaves Cotton	Bombay
Batliboi, J.	Crompton and Co.	Bombay
Beames C. F. A. M. I. E. E.	Mysore Govt.	Bangalore
Bell, C. H.	Callender's Cable	Bombay
Bent, W.	Crompton and Co.	Calcutta
Bennett, H. B.	Elec. Sup. Tram Co.	Bombay
Best, A. J.	Richardson Cruddas	Bombay
Birnie, W. J.	P. and O. S. N. Co.	Bombay
Bonnett, C., A. M. I. E E.	Osler Ld.	Bombay
Bradshaw, J. P.	Callender's Cable	Bombay
Brewis, J. M. A.M.I.E.E.,	Apollo Street	Bombay
Bridgnell, H. S	Osler Ld.	Calcutta
Bristowe, R. A	Siemens Brothers	Bombay
Burkinshaw, H.	Do.	Calcutta
Cameron, A.	Pauling & Co.	Lonavla
Clarkson, E. C.	G. I. P. Ry.	Bombay
Colin, A., A.M.I.E.E	Osler Ld.	Calcutta
Cooper, A. T., M.I E.E., A.M.I.E.E.	Elec. Sup Tram Co.	Bombay
Crawford, A. A. A.M.I.E.E.,	Medows Street	Bombay
Darukhanawala, A. B.	Apollo Bunder	Bombay
Debruislais, L.	Siemens Brothers.	Calcutta
De Souza, O. L.	Osler Ld.	Calcutta
Donald, A.	Elec. Sup. Corp.	Calcutta
Dryden, H. W.	Mysore Govt.	Mysore
Duff, D. S. A.M.I.E.E.	Osler Ld.	Madras
Dwarkanath, B. D.	Mysore Govt.	Bangalore
Dyson, J. L.	Elec. Tram. Sup. Co.	Rangoon
Eaton, G. H.	Elec. Sup. Corp.	Calcutta
Ferrario, A.	Pauling & Co.	Lonavla
Fisher, S.	Elec. Sup. Corp.	Calcutta
Garret, W. O	Siemens Brothers	Madras
Gordon, K.	Do.	Calcutta
Gibbs, H. P., M I.E.E.	Tata Hydro-Elec. Co.	Bombay
Gray, P. V.	Elec. Sup Tram Co.	Bombay
Greensted, P. W..	V. J. T. Institute	Bombay
Griffin-Chave F T.	Osler, Ld.	Calcutta
Griffin, J. W., A.M.I E E.	Elec. Tram. Light Co.	Delhi
Griggs, J. W.	Elec. Sup. Corp.	Calcutta
Hari Charan Mukerjee, A M.I E.E.	Osler, Ld.	Calcutta
Harris H. D.	Crompton & Co.	Madras
Heath, F.	Tata Hydro-Elec Co.	Bombay
Hecquet, H.	Siemens Brothers	Calcutta
Hendrey, W. G.	Callender's Cable	Calcutta
Hetherington, C.	Elec. Sup. Co.	Calcutta
Hotz, R.	Greaves, Cotton Co.	Bombay
Hurlbatt, D. G	Siemens Bros.	Bombay
Ines, E. C.	Elec. Sup. Corp.	Calcutta
Iyengar, S. D. S.	Mysore Govt.	Bangalore
Jackson, P. S.	Siemens Srothers.	Madras
Jewett, A. C.	Amir's Plant	Kabul
Jones, J. F. A.M.I.E.E.	Electric Tram Co	Madras
Joyner, R. B., C I.E., M.I C E.	Tata Hyd. Works	Lonavla
Kadaba K. A. L.C E.	Osler Ld.	Bombay
Linde R.	Siemans Brothers	Calcutta
Lockhart, W.A.	Osler Ld.	Calcutta
Mallett, G.	Chief Elec. Engr.	Kabul
Marshall, N. M.	Esplanade Road	Bombay
McCarthy Jones, C. M I E E ,A M.I.M.E.	General Elec. Co.	Calcutta
McCarthy J , A.M.I.E.E.	Osler Ld.	Calcutta
McMullen, A.	Osler Ld	Bombay
Mersh, C.M B.	Crompton & Co.	Bombay
Mertens J. T.	Calcutta Elec. Sup Corp.	
Milchem, A. G.	Osler Ld.	Calcutta
Miller, E. D. B. A.M I.E E.	Turner, Hoare & Co.	Bombay
Moberly, C. N. A.M.I.E.E.,	Elec. Sup. Tram. Co.	Bombay
Morgan, C. H.	Crompton & Co.	Bombay
Morris, N.	Osler Ld,	Calcutta
Narasimmaiengar, G R.	Mysore Govt	Bangalore
Nelson Banett, J.N.	Osler Ld.	Bombay
Ormsby, O. C.	Pauling & Co.	Lonavla
Packhan, W. B.	Calcutta Tram Co.	Calcutta,
Parry, T. D. A.M.I.E.E.	Crompton & Co.	Bombay
Penny, R.	Elec., Sup. Corp.	Calcutta
Pepper, W. R.	Calcutta Tram Co.	Calcutta

Perreira, W.	Osler Ld.	Bombay
Phillips, P. M.	Osler Ld.	Calcutta
Preston, K.	Siemens Brothers	Calcutta
Pursey, H. S.	Calcutta Tram Co.	Calcutta
Rackstram, J.	Crompton & Co.	Calcutta
Rayfield, J. H.	Osler Ld.	Calcutta
Read, R. F. A.M.I.E.E.	Turner, Hoare & Co.	Bombay
Richards, S H.	Elec. Sup. Corp.	Calcutta
Richards, B. D.	Tata Hyd. Elec. Co.	Bombay
Richards, E. V.	Do.	Do.
Richardson. H. L. A.M I.E.E.,	Richardson Cruddas,	Bombay
Robins, F J., M I.E.E.	Osler Ld.	Calcutta
Robertson J.	Crompton & Co.	Bombay
Roberts, W.	Callender's Cable	Bombay
Robinson, C.	Telephone Co.	Bombay
Rose, W. C.	Callender's Cable	Bombay
Safdarali, S.	Osler Ld.	Calcutta
Saunders, E. S.	Siemens Brothers	Calcutta
Saunders, J. B. M I.E.E	Telephone Co.	Bombay
Seale, E. J.	Tata Hyd-Elec. Co.	Bombay
Seervai, J. F.	Hughes Road	Bombay
Sethna, B. P.	Tardeo Road	Bombay
Sharp P. A.	Pauling & Co.	Lonavla
Simkin, F. H.	Osler Ld.	Bombay
Simpson, R. S.	Siemens Brothers	Madras
Simpson, A. M.	Brush Elec. Co.,	Bombay
Speyer, E. W M.I.E.E.	New China Bazar	Calcutta
Steele, E. A.	Telephone Co.	Bombay
Stowe, H. J. D.,	Lancashire Dynamo and Motor Co.	Calcutta
St. John Dixon A. O.	Callender's Cable	Bombay
Street, P. H.	Siemens Brothers	Bombay
Stanley Smith, R	Elec. Sup. Corp	Calcutta
Thibaut, E. G.	Elec. Sup. Corp.	Calcutta
Todman, M.I.E.E.,	Elec. Eng. Agency,	Bombay
Trupp, F. E.	Siemens Brothers.	Madras
Wade, G. V.	Elec. Sup Corp	Calcutta
Watson, R M.	Osler Ld.	Calcutta
Watson, H. M.	Crompton & Co.	Do.
Weaver, W.	Do.	Do.
Webb, T. D.	Calcutta Tram. Co.	Calcutta
Webb, W.	Holland & Co.	Bombay
Well, A. O. T.	Crompton & Co.	Calcutta
Weston, R. J.	Do.	Madras
Wilkie, J.	Osler Ld.	Calcutta
Willams, G. S.	Elec. Sup. Corp.	Calcutta
Wilson, A. F.	Elec. Tramways Ld.	Madras
Willis F. W.	Tata Hyd.-Elec., Co.	Bombay
Winkfield	Elec. Sup. Corp.	Calcutta
Wise, G. M A.M.I.E.E.	Apollo Street	Bombay

Electrical Plants and Machinery in India.

The undermentioned firms, who have been advertising in the *Indian Textile Journal*, have supplied almost the whole of the machinery and plant for the Electrical Installations so far put up in India.

MANUFACTURERS.	AGENCIES OR OFFICES.
A. E. G. Lahmeyer Co., Frankfort	Speyer & Co., 2, New China Bazar St., Calcutta.
British Insulated & Helsby Cables, Ld., Liverpool.	W. H. Brady & Co., Church Gate Street, Bombay.
British Westinghouse Elect. & Mfg. Co., Ld., London.	W. H. Brady & Co., Church Gate Street, Bombay
Brush Electrical Engineering Co., Ld., London.	Branch Office, Canada Buildings, Bombay.
Callender's Cable & Construction Co., Ld., London.	Killick, Nixon & Co., Home Street, Bombay.
Crompton & Co., Ld., Chelmsford.	Branch Office, Apollo Street, Bombay.
General Electric Company, New York.	Branch Office, 20, Lal Bazar Street, Calcutta.
Lancashire Dynamo & Motor Co., Ld., London.	Sorabji Shapurji & Co., Apollo Street, Bombay
Mather & Platt, Ld., Manchester.	Macbeth Brothers & Co., Hornby Road, Bombay
Osler, F. & C., Ld., London.	Branch Office, Hornby Road, Bombay.
Siemens Bros., Dynamo Works, Ld., London.	Branch Office, Rampart Row, Bombay.

Electrical Power Stations and Plants in India.

(Working and in Course of Erection.)

Ahmedabad Cotton Mill	Ahmedabad
Akola and Mid Ind. Gin. Fac.	Akola
Anglo Indian Jute Mill	Calcutta
Apollo Cotton Mill	Bombay
Assam Oil Mill	Assam
Baroda State Plant	Baroda
Bengal Iron & Steel Works	Barrackpur
Bengal Nagpur Railway Works	Calcutta
Bengal and North West Rail.	Lahore
Birkmyre Bros. Jute Factory	Calcutta
Bikanir City Flour Mill	Bikanir
Bikanir City Oil Mill	Bikanir
Bikanir State Plant	Bikanir
B. B. & C. I. Railway Works	Bombay
Bombay Cotton Mill	Bombay
Bom. Elec. Tram. & Pow. Co.	Bombay
Bombay Flour Mill	Bombay
Bom. Municip Sewage Works	Bombay
Bombay United Mills	Bombay
Buckingham Mills	Madras
Budge Budge Mills	Calcutta
Burmah Railway	Rangoon
Burma Oil Co.'s Depot	Rangoon
Bombay Telephone Co., Ld.	Bombay
Calcutta Electric Supply Co.,	Cossipore
Calcutta Ordnance Department	Cossipore
Calcutta Real Property Co.	Calcutta
Calcutta Telegraph Department	Calcutta
Calcutta Elec. Sup. Corp.	Calcutta
Cauvery Falls Works	Mysore
Cawnpore Harness Factory	Cawnpore
Caxton Printing Works	Bombay
Central Jute Press	Calcutta
Civil Engineering College	Sibpur
Colaba Land Cotton Mill	Bombay
Colombo Tramway Co.	Ceylon
Cossipore Gun and Shell Factory	Cossipore
Crescent Cotton Mill	Bombay
Crown Cotton Mill	Bombay
Currimbhoy Cotton Mill	Bombay
Cordite Water Power St.	Nilghiris
David Cotton Mill	Bombay
Dawn Cotton Mill	Bombay
Delhi Tramway Co.	Delhi
Dum Dum Ammunition Fact.	Dum Dum
East India Coal Co.	Calcutta
East Indian Railway Works	Calcutta
E. Pabaney Cotton Mill	Bombay
E. D. Sassoon Cotton Mill	Bombay
Elphinstone Cotton Mill	Bombay
Empress Cotton Mill	Nagpore
Fazalbhoy Cotton Mill	Bombay
Finlay Cotton Mill	Bombay
Fort William Flour Mill	Calcutta
G. I. P. Railway Works	Bombay
Gokak Water Falls	Belgaum
Gold Mohur Cotton Mills	Bombay
Government P. W. D.	Ootacamund
Government Press	Madras
Government Printing Press	Yeravda
Government Secretariat	Calcutta
Gwalior State Plant	Gwalior
Gwalior State Railway	Gwalior
H. M. Mint	Calcutta
Hindoosthan Cotton Mill	Calcutta
India Jute Mill	Calcutta
Ind. Bleaching, & Print. Works	Bombay
Indore State Installation	Indore
Industrial School	Lucknow
Jacob Sassoon Cotton Mill	Bombay
Jamadaba Colliery	Jamadaba
Jamshed Cotton Mill	Bombay
Jubilee Cotton Mill	Bombay
Kolar Gold Fields Plant	Mysore
Madhawji Dharamsey Cot Mill	Bombay
Madras Electric Sup. Corp.	Madras
Madras Portland Cement Works	Madras
Madras Telegraph Department	Madras
Madras Corpo. Plant	Madras
Mahmedbhoy Cotton Mill	Bombay
Mathematical Institution	Calcutta
Monarch Flour Mill	Calcutta
Madras Elec. Tramways Ld.,	Madras
Munnar Hyd Elec. Works	South Ind.
Mussorie Hyd Elec. Plant	Mussorie
Nepal State Hydro Elec. Works	Nepal
New City Flour Mill	Calcutta
New City of Bombay Cotton Mill	Bombay
New Kaleewarar Cotton Mill	Coimbatore
North Western Railway Works	Lahore
Noondydroog Mines	Mysore
Ocean Jute Press	Calcutta
Oudh and Rohilkhand Raily.	Oudh.
Patiala State Plant	Patiala

Phœnix Cotton Mill	Bombay	Simla Hydro-electric Works	Simla
Pondicherry Electric Inst.	Pondicherry	Sun Cotton Mill	Bombay
Quetta Residency Station	Quetta	South Indian Railway	Nagapatam
Quetta Staff College	Quetta	Taj Mahal Hotel	Bombay
Rangoon Elec. Tramway	Rangoon	Tata Swadeshi Mill	Bombay
Ranigunj Colliery	Ranigunj	Tata Hydro-electric Works	Lonavla
Ripon Cotton Mill	Bombay	Tata Iron and Steel Works	Kalimati
Sarah Bridge Plant	Sarah	Thomason Engineering College	Roorkee
Sun Jute Press	Calcutta	Tibutil Gold Mines	Anantpur
Swan Cotton Mill	Bombay	The Times Press	Bombay
Suraj Jute Press	Calcutta	Upper Swat Canal	Malakand
Sorab Cotton Mill	Bombay	Victoria Jute Press	Calcutta
Srinagar Hydro-elec. Works	Kashmir	Western India Cotton Mill	Bombay
Shri Buldeo Cotton Mills	Hathras		

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SIR DORABJI J. TATA, KT.

THE LATE MR. J. N. TATA.

H. E. SIR GEORGE S. CLARKE, G.C.M.G., G.C.S.I., G.C.I.E.

HON. SIR SASSOON DAVID, BARONET.

SIR SHAPURJI B. BROACHA, KT.

THE LATE MR. DAVID GOSTLING, F.R.S.A.

CUBIC CAPACITY AND HEIGHT OF LAKES FROM SEA LEVEL.

	Height in Feet.	Cubic Feet.
Lonavla Lake	2,050	378,000,000
Walwhan Lake	2,084	2,560,000,000
Shirwata Lake	2,158	6,964,000,000

THE TATA HYDRO-ELECTRIC PROJECT.

DIAGRAM OF THE DISTRICT.

SCALE THREE MILES TO ONE INCH.

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