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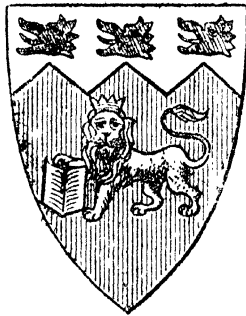
for a

University Department of Chemical Technology.

REPORT

OF THE

COMMITTEE APPOINTED BY THE ACADEMIC COUNCIL.



Published by the University of Bombay.

PRINTED AT DIDMUS P. PRESS, FC

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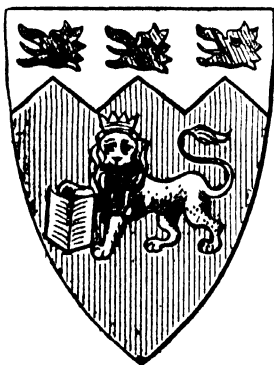
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SUMMARY OF REPORT.

TECHNOLOGICAL EDUCATION.—Technological education, that is, technical education of university standard, aims at training men who will take part, first, as assistants, and later, as superintendents, managers and directors, in the control and the initiation of important industrial and business undertakings. Instruction of a university standard has been given in this country in civil engineering and in agriculture for many years. A beginning was made, some years ago, in mechanical engineering and, more recently, in electrical engineering and in applied chemistry, but there is no college of technology giving instruction of a comprehensive character anywhere in India.

CHEMICAL TECHNOLOGY.—It is known that the applications of chemistry in industry are innumerable and that India exports raw materials and imports manufactured goods in immense quantities. Hence an urgent need at this moment is a supply of men trained in technological chemistry to develop the manufactures of the country.

The special feature of training in chemical technology is chemical engineering, a knowledge of which is needed for the design, construction and operation of the plant used for carrying out chemical processes in industry.

ACTION BY THE BOMBAY GOVERNMENT AND THE UNIVERSITY.—A Committee, appointed by the Government of Bombay in 1921, submitted proposals for the extension of technical education of all grades in the Bombay Presidency. It recommended the constitution of a faculty of technology in the University and the establishment of a college of technology in the City of Bombay to give instruction in mechanical engineering, electrical engineering, textile industries and applied chemistry.

In the year 1925, a Committee on University Reform, appointed by the Bombay Government, also

recommended the constitution of a faculty of technology, and the establishment of a college of technology in Bombay.

When it became evident that a sum of Rs. 10 lakhs, in the shape of bequests and endowments, was likely to be available, the Academic Council of the Bombay University appointed the present Committee to draw up a scheme for a University Department of Chemical Technology. Preference was given to chemical technology, on account of the value of the help which experts in that subject would be able to render to the staple industry of this Presidency, namely, cotton textiles.

OUTLINE OF SCHEME.—The subjects to be taught under chemical technology fall under three main heads: (1) fundamental, (2) required and (3) elective.

The fundamental subjects are mathematics, physics and chemistry. The required subjects suggested are elementary engineering, mechanical, electrical and chemical; economics and business administration; and German.

Provision is made for three elective subjects namely, (i) chemical engineering, (ii) textile chemistry and (iii) industrial chemistry. The student will take up one of these three as an optional subject.

The student should have passed the Intermediate Science Examination of the University before admission to the course for the Degree of Bachelor of Science in Technology. The course will extend over three years. *Fundamental* subjects should be completed in the first two years and *elective* subjects in the last two, the *required* subjects being distributed over all three as may be found convenient.

Provision is made for 120 students in all, the yearly admission of fresh students being taken at 40. It is expected that 15 to 20 will graduate every year. The graduates will be eligible for positions in industries in which applied chemistry plays a part.

Provision will be made for diploma and part-time courses after the degree course is provided for and brought into operation.

FINANCIAL IMPLICATIONS.—The capital outlay required for the scheme is estimated at Rs. 6.5 lakhs and the yearly maintenance charges, during the first five years, at Rs. 1.25 lakhs. These include the cost, Rs. 1.75 lakh, of a new building, provision for the general and special apparatus and for the staff.

The Academic Council expected that contributions amounting to Rs. 2 lakhs and Rs. 8 lakhs respectively, would be available to meet the whole of the capital outlay and part of the recurring charges. The University in sanctioning the scheme has to make provision for the balance of money needed to cover recurring charges.

ACTION FOR THE FUTURE.—In view of the fact that the major industries of India are exposed to world competition, that industries of all kinds require expert guidance, and that many new industries have yet to be started, the Committee attaches special importance to the opening of this department without delay. It accordingly recommends that the work of the first year in the degree course, which is elementary, and which will be taken by 40 students at most, should begin in the ensuing academic year, that is, in June 1931.

The first step to take is to make sure that the necessary funds are available, the next, to award general sanction to the scheme, and, lastly, to appoint a small committee and an executive officer, for about six months to begin with, to work out the details for the execution of the scheme.

The duties of this committee and officer will be:

- (1) to develop the details of the project in respect of finance, construction and equipment, and
- (2) to make preparations to start the first year's course in June 1931.

REPORT

CHAPTER I

INTRODUCTORY

SECTION 1. THE GROWTH OF TECHNICAL EDUCATION
IN INDIA.

The branch of technical education that was first developed in India was civil engineering. It began with the establishment at Madras in 1794 of a school of surveyors which, 63 years later, was converted into an engineering college. In Bengal an engineering school was opened at Calcutta in 1858 which became an engineering college 30 years later. In the United Provinces an engineering college was opened at Roorkee in 1847. In the Bombay Presidency an engineering class and mechanical school to teach the elements of civil and mechanical engineering was started in Poona in 1854; this institution in 1866 was raised to the status of an engineering college affiliated to the University of Bombay. All these four institutions have from their inception been supplying engineers and upper subordinates for service in the Public Works Department of the various provincial governments.

2. The suggestion that technical education should be provided by Government was first made in the report of the Famine Commission in 1880. This was followed in 1884 by the Report of a Royal Commission which directed attention to the necessity for developing the material resources of India and of helping Indian artisans in their struggle against the products of the factories and mills of the West. In a resolution on the subject of technical education, of the 18th June, 1888, the Government of

India pointed out that education, as hitherto provided, had been excessively literary in character and that technical education was required in order to lead to a greater variety of occupations. It called upon the local governments to give a more practical bias to general education. But the immediate response to this reference was small. This was followed by the Simla Educational Conference of 1901. The chief practical outcome of this conference was the institution of ten state scholarships for the study in foreign countries of subjects connected with industrial science and research. This was a distinct advance in the attempt to provide India with trained technical men. The Clibborn Committee on Industrial Education reported in 1903 that training schools for instructors in wood, iron and mechanical industries should be established. The principle emphasised by this Committee was that the object of industrial schools must be to impart skill in a specialised manner. This Committee was followed in 1912 by that of Atkinson and Dawson which was asked to propose measures for bringing technical schools into closer touch with industries and with employers of labour. The Government of India issued in 1913 a comprehensive resolution on their educational policy in which it was declared that technical and industrial education in each province should be related to local industries and should be the concern of the provincial governments.

3. The industrial policy of Lord Hardinge's government is set forth in a despatch, dated the 26th November 1915, to the Secretary of State for India. The despatch asserted the "need for an industrial policy which will enable technical education in India to produce its best results and which will lighten the pressure on purely

literary courses and reduce the excessive demand for employment in the services and callings to which these courses lead..... After the war, India will consider herself entitled to demand the utmost help that her Government can afford to enable her to take her place, so far as circumstances permit, as a manufacturing country." This pronouncement was supplemented by Sir William Clark who stated, in the Imperial Legislative Council, that "the building up of industries where the capital, control and management should be in the hands of Indians" was "the special object which we all have in view." Finally, Lord Chelmsford stated that "we do not want mere Indian capital, we want Indian men and not Indian men only as labourers, but as leaders who will turn their attention to industrial enterprise and equip themselves for a great industrial regeneration in India."

4. The despatch quoted above was followed up by the appointment of the Indian Industrial Commission (1916-18) over which Sir Thomas Holland presided. On the subject of industrial education, this Commission drew an important distinction between technical education and technological education, a distinction which is considered and adopted in Chapter II of this report. The Commission came to the following noteworthy conclusions:—

- (i) "it is urgently necessary to prepare for a higher technological training.....whereby the physical science students of the colleges affiliated to the Universities may learn to apply their knowledge to industrial uses,"
- (ii) "the engineering colleges should make provision for the higher technical instruction of mechanical and electrical engineers" and
- (iii) "industrial expansion will justify the starting of departments of general technological chemistry."

5. The scheme of state scholarships for industrial studies, which is mentioned in paragraph 2, was supplemented in various ways. Scholarships were founded at the Universities, various funds were established and an association was formed in Calcutta, as a result of the Swadeshi movement in Bengal, all serving the same purpose, namely, of sending young Indians abroad for study with a view to the ultimate benefit of Indian industry. But these Indians in foreign countries, who were readily admitted to educational institutions for industrial studies, found it difficult to get admission to factories where, by continued practice in the methods and processes there employed, they could have gained the experience needful to complete their training.

6. Mr. Jamsetji Tata, in 1898, announced his intention of promoting scientific study and research, with a view to the benefit of industry throughout India, by means of a gift of Rs. 30 lakhs. He invited Sir William Ramsay to advise him and to draw up a scheme for the purpose. Consequent on Mr. Tata's action, and with support from the Government of India, certain Provincial Governments and the Mysore State, the Indian Institute of Science was founded at Bangalore and commenced work in 1911. This Institute has had a chequered history into the details of which it is not necessary to enter. It gives a systematic training in electrical technology and carries on original work in that subject, in physical, inorganic and organic chemistry and in bio-chemistry. There has been a steady output of original papers in these subjects, many of them having an industrial bearing. But this Institute does not give systematic courses of instruction in the application of science to chemical industry. Some provision

for such instruction, however, has been made elsewhere: at the Calcutta University, the Hindu University, Benares, the Punjab University and the Harcourt Butler Technological Institute, Cawnpore.

SECTION 2. TECHNICAL EDUCATION IN THE BOMBAY PRESIDENCY.

7. Effort in the Bombay Presidency, as was shown in Section 1, led to the establishment of the College of Engineering in Poona. The government of Lord Reay in 1886 issued a resolution on technical education in the Bombay Presidency: as one result the Victoria Jubilee Technical Institute came into existence in 1888, its objects being the instruction of apprentices, workmen, foremen and managers, the training of suitable technical teachers and the holding of examinations in technology. This Committee records here the name of Tribhuvandas Kalliandas Gajjar, because of the exertions that he made for the advancement of techno-chemical education and industry in western India: he was chiefly instrumental in the establishment of a technical school at Baroda in 1897, namely, the Kala Bhuvan: he pressed the suggestion that the processes of bleaching and dyeing should be carried on in the cotton mills of Bombay and Ahmedabad: he was the chief agent in the establishment at Baroda of the Alembic Chemical Works. The College of Agriculture, Poona, was established in 1907. The Ranchhodlal Chhotalal Technical Institute was started at Ahmedabad in 1910. The Nadirshaw Eduljee Dinshaw Civil Engineering College at Karachi was opened in 1923. Progress in secondary and primary technical education was marked by the opening of small technical and vocational schools at Satara, Dhulia, Ratnagiri, Poona,

Manmad, Pandharpur, Surat, Jacobabad, Sirur, Baramati, Sholapur, Ahmednagar, Nadiad, Borsad, Karachi, Hyderabad (Sind) and Sukkur and of several in Bombay City.

8. There was thus a growing demand for technical education in the Bombay Presidency and an effort to meet the demand. The necessity for organisation was realised in 1912 when the Board of Trustees of the Victoria Jubilee Technical Institute made proposals whereby technical education should be systematically developed. On consideration of these proposals the Government of Bombay appointed a Committee of Direction for Technical Education. In 1921, following on the publication of the Holland Commission Report, the Government of Bombay appointed a Committee on Technical and Industrial Education in the Bombay Presidency which was presided over by Sir M. Visvesvaraya. That Committee was asked to prepare a report which should include suggestions for vocational training and for the co-ordination and development of technical education. In March 1922 the Committee submitted its report, the first of its kind in India, surveying the subject in every aspect and embodying valuable suggestions for the advancement of technical and technological education.

9. In particular that Committee recommended (i) that the University of Bombay should constitute a faculty of technology and (ii) that a college of technology should be established in Bombay City.

SECTION 3. TECHNICAL EDUCATION IN THE UNIVERSITY OF BOMBAY.

10. The University of Bombay, which was incorporated in 1857, laid down in 1865 courses in civil engineer-

ing for the Licentiate of Civil Engineering degree. Courses leading to the Bachelor of Science degree were laid down in 1881. After this progress was slow. Courses leading to the degree of Licentiate of Agriculture were started in 1889 and subsequently courses leading to the Bachelor of Agriculture degree. In 1917, the University laid down courses in mechanical engineering leading to the Bachelor of Engineering degree. But it is not yet possible to take this degree with electrical engineering, in spite of the great advance that has been made, in this part of India, in the generation and use of electricity.

11. Following up the recommendation of the Visvesvaraya Committee (1921-22), Dr. Viegas proposed in the University that a faculty of technology be instituted. Before a decision on that proposal had been reached the Government of Bombay appointed a Committee on University Reform. That Committee, in the report which it made in 1925, recognised that the "aim of a university is to inculcate the desire for truth and to fit man for the application of sound principles to life" and that in a university humane studies and instruction in applied science ought to be carried on side by side.

12. The same Committee observed that existing institutions in Bombay and Ahmedabad did not supply technical education of the standard that a university must require. It referred to a passage, in the report of the Visvesvaraya Committee, which runs thus:— "Any one conversant with the conditions under which the existing industries in India are carried on will readily realise how greatly the industries are handicapped for want of competent men to conduct them and will recognise the importance of training experts and leaders from among the people to superin-

tend, direct and manage local undertakings. The men required for these duties are, with a few exceptions, imported from abroad, and the high salaries which have to be paid to them are a great drawback in existing industries and a serious deterrent to new enterprises. The recent development of industries in Europe and America has made it increasingly difficult to obtain suitable recruits even at high salaries and the concurrent development of our own industries is rapidly outgrowing the possibilities of recruitment from foreign sources. Unless therefore immediate and bold steps are taken to train a sufficient number of technical experts in the country itself, our industrial development is likely to be seriously retarded. Such training can be given either by opening a Technological College in this country or by sending students to receive training abroad. The latter course, in addition to being expensive, is open to the serious objection that the large number of experts required cannot be speedily obtained in that way."

13. The Committee on University Reform, in concurrence with the Visvesvaraya Committee, recommended that the University should constitute a faculty of technology and that a college of technology should be established in Bombay City. The following are its suggestions in detail:—

- "i. It is desirable to open a Technological College in Bombay of which one or two Departments may be located in the Royal Institute of Science as explained below.
- ii. When such a College is instituted the University should create a Faculty of Technology, to include Engineering (Civil, Mechanical and Electrical), Agriculture and other technical and

applied sciences, the existing Science Faculty being restricted to Pure Science. The Faculty of Technology should include laymen (*i. e.*, those who are not professional educationists) with special knowledge of the industries concerned.

- iii. The subjects to be taught in such Technological College should be Mechanical Engineering, Electrical Engineering, Textile Industries and Applied Chemistry. We think that graduates in these subjects are likely to be absorbed in industries more quickly than in others, the railways, irrigation projects and mills being likely to have an increasing number of superior appointments to offer. And in view of the heavy expenditure involved we have recommended that provision should in the beginning be made for 200 students.
- iv. Admission to the Technological College should be after the first year's study in an Arts College, normally on the Science side, but also, with the approval of the authorities of the Technological College, on the Arts side.
- v. There should be a three years' course for a Bachelor's degree in Technology; ultimately a further two years' course might be created leading to a Master's degree in Technology to be awarded on approval of a thesis. "The aim of every course of training given in a technological department should be clearly defined, and the certificate (whether a degree or a diploma) should in each case plainly

signify the kind of work for which, in the judgment of the University, the holder is qualified" (Calcutta Commission Report, Chap. 48, Sec. 18.)

- vi. We also approve of the recommendation of the Calcutta Commission (Chap. 48, Sec. 16) that there should be an advisory committee for each department including representatives of the industries concerned and scientists representing the University, and recommendations of the Faculty should go to this advisory committee in the first instance.
- vii. The nature and amount of the practical training to be required of technological students, is a debatable point. Actual works experience, says Prof. J. F. Thorpe, Professor of Organic Chemistry, Imperial College of Science and Technology, London, is strictly a necessity for true technological training. But in practice, he continues (speaking of chemical works), such works or factory experience is apt to be limited to routine work in the research laboratory, since chemical manufacturers are loth to give the run of their works to casual students not in any way bound to them. In India, any factory experience is hard to obtain. He suggests as the best substitute for this instruction, in laboratories attached to the universities, the use of appliances, not of the full industrial scale (which would be unnecessary and even impossible) but of comparatively small dimensions containing types of every kind of plant used

in chemical manufacture, of about 1/60th the size of the large scale plant and involving the use of metal apparatus and the connections incidental thereto (Chemical Services Committee Report, 1920). The Calcutta Commission take much the same view (Chap. 48, Sec. 19) and are of opinion that the Technological College must be supplied with laboratories and workshops fully equipped not only for demonstration but also on the modified industrial scale suggested by Prof. Thorpe. Opportunities of experience of production on a large scale and under factory, commercial and industrial conditions must be provided by arrangement with railway authorities and factory owners and such experience must be a condition of a degree. But the responsibility for the students' practical training must devolve principally on the University."

14. The Committee recommended that the proposed technological college "should be a university institution, directly managed by the University." It observed that this college must meet two distinct requirements, one, training in mechanical and electrical engineering and in the manufacture of textiles, and the other, training in applied chemistry. The Committee recommended that a department for the one set of requirements should be located at Matunga and a department for the other at the Royal Institute of Science. The Committee observes:—

"For the technological department at the Royal Institute of Science, room would be found on the two upper floors of the east wing facing the Museum. There was a proposal to utilise these

floors for a hostel but we believe this has been abandoned, and in any case we think that it would be a misuse of the space. For the hostel we have proposed a site on the Cotton Green. In addition to the east wing, new buildings may be erected on the chord of the arc of the Institute compound. The department, to begin with, should be one of Applied Chemistry. It would, we suggest, require special laboratories equipped not on a full industrial but a comparatively smaller scale, containing types of the principal kinds of plant used in chemical manufacture as recommended by Prof. Thorpe. We suggest, (subject of course to the approval of experts) that this department of Applied Chemistry might undertake some of the following branches :—

- i. Chemical Engineering (*i. e.*, the scientific design and operation of the apparatus and processes of chemical industry);
- ii. General Chemical Technology, (*i.e.*, industrial, organic, inorganic and physical chemistry);
- iii. Chemistry of Textiles;
- iv. Colouring matters;
- v. Possibly such others as fuel, food-stuffs, electro-chemistry, indigenous drugs and photography."

15. The Committee estimated the cost of the technological college by departments as follows:—

	At Matunga	At the Royal Institute of Science.
Site, buildings and fittings... ..	Rs. 45 lakhs.	Rs. 5 lakhs.
Recurring charges	„ 3½ „	„ 1 „

SECTION 4. ORIGIN OF PRESENT PROPOSALS.

16. The Bombay University Act (1928) makes an advance, on the Acts that it supersedes, in a way that is notable for the present purpose. The preamble to this Act declares *technology*, for the first time in the history of the University, to be one of the branches of learning for which the University should provide facilities.

17. The Advocate General, in 1929, informed the Syndicate that a donation, of property valued at Rs. 2,02,000, would be made to the University on the condition that a chemical laboratory should be established in the University and be named after Tulsidas Soorji to whose estate the property belonged.

18. In 1928, Dr. Viegas submitted to the University a proposal for the establishment of a college of technology. This proposal, when the Senate was about to consider it, was found to be out of order for technical reasons connected with the operation of the new Act. Dr. Viegas, therefore, submitted his proposal anew to the Syndicate which referred it to the Academic Council for consideration and report.

19. The Academic Council, when this proposal came before it in March 1930, recognised the need for a college of technology in Bombay, but could

not recommend that the proposal be accepted because it would involve outlay far beyond the resources of the University.

20. The Academic Council, at the same meeting, considered Mr. K. M. Munshi's proposition for the institution of a University Department of Chemical Technology, which runs as follows:—

“1 To the best of my information the Government is inclined to place at the disposal of the University the unoccupied wing of the Royal Institute of Science for a University Department of Chemical Technology.

2. The University will receive a sum of Rs. 2,00,000 for a laboratory for such a College from suits Nos. 3697 of 1925 and 2034 of 1926. To my knowledge, a sum of Rs. 8,00,000 is likely to come to the University under the will of a deceased gentleman. Thus the University will have sufficient funds to start a University Department of Technology as proposed.

3. I, therefore, propose to move before the Academic Council the following resolution:—

That a Committee consisting of the members of the Board of Chemistry, Dr. N. A. F. Moos, Prof. K. R. Kanitkar, Mr. Kapilram H. Vakil, Fellows of our University who have expert knowledge in Technology, Mr. M. S. Patel, M.Sc., Ph.D., (Cornell), Industrial Chemist to the Government of Bombay, be appointed to draw up a detailed scheme of a University

Department of Chemical Technology and Sir M. Visvesvaraya, be invited to be the Chairman of the Committee.”

21. The proposition was carried and, in response to the invitation of the Academic Council, this Committee undertook the preparation of the scheme referred to.

22. The scheme provides for training in Chemical Technology only. The remainder of the large programme of instruction in applied science, contemplated by the Committee on University Reform, is left to the future.

CHAPTER II

GENERAL OBJECTS AND SCOPE OF SCHEME.

SECTION 1. THE OBJECTS OF TECHNOLOGICAL EDUCATION.

23. THE NATURE OF THIS REPORT.—This report might have consisted mainly of proposals and an estimate of costs, if it had been meant only for the consideration of experts in technological education. But as it will presumably be made public, the Committee feels that something more than a brief report for experts is expected of it. On this ground an attempt has been made to give reasons in explanation and support of the proposals and to present the report in such a manner that laymen can follow the argument and appreciate the importance of the subject.

24. IDEAS ON EDUCATION IN APPLIED SCIENCE.—The Committee on University Reform (1924-25) remarked that “many witnesses recommended in a general way the creation of a Faculty of Technology without furnishing any justification in principle or any clear idea of what is therein involved.” It is certain that many people, in thinking of instruction in applied science, picture an institution, containing miniature factories and workshops, where one industry after another is carried through all its stages so as to produce men who are skilled in making various commercial articles. This is not instruction in applied science as it is now understood.

25. TECHNICAL AND TECHNOLOGICAL EDUCATION.—The term “technical education” has so far been used in the general sense. But the Holland Commission felt the need of distinguishing between “technical” and “technological” education. This is an important distinction

which is not sufficiently recognised in the popular mind and even in academic circles. It is often said that, because facilities for technical education are provided in the Victoria Jubilee Technical Institute in Bombay and in technical schools at Ahmedabad, Baroda and Karachi, there is no need to provide technological education in the University.

26. **TECHNICAL EDUCATION.**—Technical education means a special training, based on the application of scientific principles to mechanical arts, crafts and industries, that leads to better handling of tools in the workshop, renders operatives more skilful and intelligent than untrained operatives in attending to a process, and enables them to meet minor difficulties as they arise. It affords a supply of intelligent men who become foremen in course of time.

27. **TECHNOLOGICAL EDUCATION.**—Technological education aims at producing men who can attack a new problem systematically, can frame a scheme for a project and furnish it in detail and can direct and control operations. A trained intelligence, rather than manual skill, is needed for such purposes.

28. The Manchester Municipal College of Technology illustrates what has just been said. It is the outcome, by evolution, of the Manchester Mechanics' Institution which was founded in the year 1824. The Manchester Mechanics' Institution used to provide "popular lectures by learned men in science and literature; it arranged industrial exhibitions, exhibitions of fine art and popular concerts of a refined and elevating character." About the year 1883, "specialised senior courses of instruction for day students were organised in chemistry, in engineering

and in the textile industries." The College now offers "systematic training in the principles of Science and Art, as applied to Mechanical Engineering, Electrical Engineering, and Municipal and Sanitary Engineering; the Building Trades; the Chemical Industries; the Textile Industries; Mining; Photography and the Printing Crafts." The courses of instruction at the College are varied and numerous: they include part time day and evening courses, senior technical and vocational courses extending over two years, full time courses extending over two years in the Department of Industrial Administration and over three years in the Building Department, and University courses in the Faculty of Technology and in advanced study and research. The College is a constituent part, in respect of its higher activities, of the Victoria University of Manchester; a number of its teachers are recognised by the University, its professors belong to the Faculty of Technology and it prepares students for university degrees.

29. Technological education is given at universities and at institutions of university standing because it means liberal knowledge in applied science. For instance the Articles of Incorporation of the Carnegie Institute of Technology at Pittsburgh declare —

"that the objects of the Corporation shall be to encourage in the broadest and most liberal manner investigation, research, discovery and the application of knowledge to the improvement of mankind."

Again, the University of Michigan, quotes the definition of civil engineering, that was given in the 18th century by the Institution of Civil Engineers, as "the art of directing the great sources of power in Nature for the

use and convenience of man”, and proceeds to say that, if broadly interpreted, it is still a good definition. The University then states in philosophical language, with respect to engineering, the principles on which, modern education in applied science is based:—

•

“The first object of engineering education is to produce an attitude of mind. A second, is to supply the substratum of fact that may serve as the basis, and tools that serve as a means for building and erecting thought structures of analytical reasoning. A third, is to supply inspiration and guidance in the translation of thought into action and accomplishment. Finally, there should be engendered that perspective sense that permits the visualisation of the *raison d'être* of the whole, and that suggests its fitness, purpose and value in the work of the world. “Stated concretely rather than abstractly, this is to say that from the study of mathematics, physics, chemistry, mechanics and languages, the student should acquire, imitatively at first, habits of thought that later become intuitive. At the same time, he learns the fundamental truths of these sciences or subjects and gains the ability to use their methods in the solution of his own problems. Of these latter, he should be given many, concretely stated in the language of engineering. The professional courses offer the opportunity for this, while at the same time fixing a tangible impression or picture of the application of principle in actual practice.”

SECTION 2. THE NEED FOR TRAINING IN TECHNOLOGICAL CHEMISTRY.

30. CAPACITY OF INDIANS FOR RESPONSIBLE POSITION IN INDUSTRY.—Several witnesses before the Holland Commission, the Thorpe Committee and the Pope Committee (Special committee on the Indian Institute of Science, Bangalore, presided over by Sir William Pope) stated that the time was not yet ripe in India for appointing Indians to responsible executive positions in industrial undertakings and that experts must be imported for years to come. This opinion was partly admitted by the Holland Commission and by the Thorpe Committee. Sir P. C. Ray strongly protested against this opinion as being interested and ill-founded:—"we have graduates of the local Universities occupying conspicuous and distinguished positions as advocates-general, judges, jurists, surgeons and physicians and scientists, who can hold their own against their confreres in any country in Europe." Moreover, Indians, some of them trained abroad and some in India, have demonstrated their capacity to manage industries and take the initiative in the economic and industrial development of the country, Given equal opportunities and facilities, our young men will prove themselves equal to foreign experts. The Indian Universities have hitherto given facilities for the study of various professions, such as law, medicine and engineering. We have now to show the direction in which other facilities for professional education are needed and ought to be provided.

31. INDIA'S DEPENDENCE ON IMPORTS.—The Holland Commission laid stress on the need of increasing the provision for technological instruction on the ground of India's backwardness in industries. The Commission drew

attention to her dependence upon other countries for the manufactured articles that are necessary in the daily life of a civilised community, deplored this dependence and showed its extent by giving a list of important imports into India. This list has been brought up to date in Appendices A and B of this report. Again, a study of the export of raw materials indicates what India loses in the other direction because of her industrial deficiencies (see Appendices C and D). The Commission cited numerous industries that are lacking in India:—

“The list of industries, which, though their products are essential alike in peace and war, are lacking in this country is lengthy and almost ominous. Until they are brought into existence on an adequate scale, Indian capitalists will, in times of peace, be deprived of a number of profitable enterprises whilst, in the event of a war which renders sea transport impossible, India’s all-important existing industries will be exposed to the risk of stoppage, her consumers to great hardship and her armed forces to the gravest possible danger.” With the abundance of our raw materials, agricultural and mineral, with great natural facilities for power and transport, with a vast home market to absorb all that we may manufacture, it must be possible to reduce this list of industries lacking in India.

32. THE RÔLE OF CHEMISTRY IN EVERYDAY LIFE.—

People need to reflect on the rôle of chemistry in modern life and on the meaning of the word “chemist” They usually ascribe to the chemist a knowledge of drugs and of the chemicals sold in shops and they may picture him carrying on chemical analysis. But chemistry is essential in peace and in war, in private life and in public callings, in fields and in cities. Chemistry and the chemist are requir-

ed for the manufacture of innumerable articles that are used every day by innumerable people. From the time a man gets up in the morning till he goes to bed at night, from the day he is born till the day he is dead, in health and in sickness, he uses hardly an article in the making of which chemistry is not involved.*

33. THE NEED FOR TRAINING IN TECHNOLOGICAL CHEMISTRY.—Thus India goes on importing goods and exporting raw materials and goes on depending on men trained abroad for conducting the industries that she has. She can enable young Indians to turn raw materials into goods by giving them a training of high quality in technological chemistry within her own borders.

34. As was shown in Chapter I, recommendations regarding technological education were made to the University by the Committee on Technical and Industrial Education in the Bombay Presidency (1921-22) and, in concurrence with it, by the Committee on University Reform (1924-25). The University was advised to establish a technological college where a training should be given in mechanical and electrical engineering, in textile industries and in applied chemistry. But the cost, initial and recurring, of such a college is beyond the resources of the University. Hence the Academic Council, making a choice, proposes to begin with applied chemistry, that is, with chemical technology.

This Committee wishes to make it clear that whilst the scheme for chemical technology follows the lines indicated in earlier reports, its efforts, of necessity, exclude a large part of the comprehensive programme demanded and approved generally by the University and public opinion.

SECTION 3 SCOPE OF PROPOSED DEPARTMENT OF CHEMICAL TECHNOLOGY.

35. There is something in common between a training in engineering and in chemical technology as given at a university. The training, going far beyond useful facts, inculcates principles and methods that can be used for solving problems as they arise. Moreover, the term "chemical technology" is replaced, at the Massachusetts Institute of Technology, for instance, by the term "chemical engineering," because a knowledge of engineering is essential in chemical industries. "The efficiency of any industrial chemical process depends not only upon a knowledge of the chemical reactions forming the basis of the process, but also upon a knowledge of the mechanical principles on which depend the design, construction and maintenance of plant for carrying on these reactions. To prepare students capable of filling the demand for men competent to build and operate manufacturing industries based upon chemical principles is the purpose of this course in chemical engineering."

36. In drafting the preamble of the present scheme the Committee has taken into consideration the scope and objects of institutions in America and England. Some of these have already been stated. Further, the Ramsay Laboratory of Chemical Engineering, University College, London, defines its scope to be, "to provide for students who have already received a thorough training in the fundamental sciences of chemistry, physics and mathematics, the necessary courses and laboratory facilities to enable them to direct their studies and investigations to the application of physics, physical chemistry and engineering to the scientific design and operation of the apparatus and processes of chemical industry in general."

37. The Institution of Chemical Engineers has defined a chemical engineer as “a professional man experienced in the designing, construction and operation of plant and works in which matter undergoes a change of state and composition.” According to this Institution “a chemical engineer should not be a highly specialised man, but rather one who possesses a thorough general knowledge of chemical reactions and physical laws, combined with a thorough grasp of the principles of mechanical and electrical engineering, and those branches of civil engineering dealing with the strength of materials and the theory and design of construction.”

38. These various definitions have arisen out of efforts to consider the increasing application of scientific knowledge to industrial operations leading to the demand for a new branch of learning. Chemical technology aims at producing men for the chemical industries who shall become, in course of time, superintendents, managers and heads of departments, even leaders of industry. Men are needed in India who can direct and control processes and plant, can effect improvements in them and can even make new products and establish new industries.

39. We propose, as the scope of this scheme:

The department of chemical technology shall give instruction in science, and afford facilities for advanced study and research, in order to prepare men to design, construct and operate plant and to control processes in industries in which matter undergoes a change of state or composition.

SECTION 4. THE DEPARTMENT OF CHEMICAL TECHNOLOGY :
FOUR CONSIDERATIONS

40. The scope of the Department of Chemical Technology, as defined in Section 3, raises four distinct considerations, viz :—

The training of undergraduates in the Department.

Training of undergraduates at works.

Experience in industry: advanced study and research.

Equipment.

41. THE TRAINING OF UNDERGRADUATES IN THE DEPARTMENT.—The foundation of applied chemistry must be a grounding in the sciences of mathematics, physics and pure chemistry. As Professor Thorpe remarked, “You cannot ‘apply’ your chemistry until you have produced your chemist.” Therefore proof of training in mathematics, physics and chemistry ought to be required as one condition of admission to the Department of Chemical Technology. This preliminary training will be completed in the Department by such instruction in these subjects as is judged to be necessary. Instruction in technical subjects will be given as detailed in Chapter III. In addition, instruction will be given in auxiliary subjects, such as German, Economics and Sociology.

42. TRAINING OF UNDERGRADUATES AT WORKS.—The Department should also introduce the student to the industrial atmosphere in which he must spend his life. This can be done by arranging—

- (a) facilities for training at works;
- (b) visits to works;

- (c) special lectures to be given by men engaged in industries who can speak with authority and knowledge based on experience.

43. **THE VALUE OF EXPERIENCE.**—Experience is as necessary in the profession of applied chemistry as in any other. No one would appoint a junior man, in medicine, law, or civil engineering, to control important professional undertakings. Harm may be done by the employment of fresh graduates in industry under the impression that control by any graduate must lead to efficiency and advancement. Employers and graduates should understand that experience is indispensable for an important executive position or for initiating an industry.

44. **EXPERIENCE IN INDUSTRY: ADVANCED STUDY AND RESEARCH.**—The fresh Bachelor of Technology is not ready to undertake a major executive position. In order to fit himself for a position, as manager or process manager, or as chemical engineer in an independent consulting capacity, two courses are open to him: (i) to begin a career at the works and there acquire experience and professional status; and (ii) to proceed to advanced study and research, supplementing this with works experience. Provision for advanced study and research ought to be made in the Department of Chemical Technology.

45. **EQUIPMENT.**—The equipment should be provided so as to facilitate the teaching in the subjects of pure and applied science that are decided on: it should be planned for the routine teaching and also for the undertaking of research problems in a wide range of subjects pertaining to applied chemistry. By providing for the latter the utility of the Department for industrial purposes will be much enhanced.

CHAPTER III

TRAINING AIMED AT.

SECTION 1. SUBJECTS OF INSTRUCTION.

46. CHEMICAL TECHNOLOGY.—An indication of what is needed for training in chemical technology can be gained from the regulations of the Institute of Chemistry. A candidate, for the Fellowship of that Institute, who offers “Industrial Chemistry,” is required to have a good *general* knowledge of chemistry, and a *fundamental* knowledge of those branches of chemistry which have close relation with the section of the industry selected. He will also be expected to have—

- (1) “A *general* knowledge of the application of well known chemical and physical laws to industrial operations; the development, control and transmission of heat and power; fittings and stores; properties of materials used in general construction of plant; process costs; working costs and economics of manufacture; a working knowledge of the operation of plant in general use in industrial chemical works.
- (2) A *specialised* knowledge of the application of the foregoing to the section of the industry selected by the candidate including the sources and characters of its raw materials; the uses of finished products; the treatment of any by-products or effluents; the technical methods of analysis employed.”

47. CLASSIFICATION OF SUBJECTS.—The subjects of study required for training in chemical technology can be placed under three heads:—

1. Fundamental;
2. Required;
3. Elective (or optional).

48. **FUNDAMENTAL SUBJECTS.**—Chemistry, physics and mathematics are the Fundamental subjects, the courses in which should be completed in the first two years. In chemistry the courses of study should be so arranged as to give the student a thorough knowledge of the fundamental laws and theories. The courses should include theoretical and practical instruction in inorganic, organic and physical chemistry and should be supplemented by lectures on the theory and practice of analysis and on the application of chemistry in the arts and industries. The instruction should be similar to that required for the highest examination in chemistry at recognised institutions or for the associateship examination at the Institute of Chemistry. Instruction should be given in such advanced portions of physics and mathematics as may be deemed necessary for problems that arise in the study of applied chemistry.

49. **REQUIRED SUBJECTS.**—The instruction in Fundamental subjects is to be accompanied by instruction in Required subjects.

REQUIRED SUBJECTS.

A. *Elementary Engineering as applied to Chemical Industries.*

Descriptive engineering.

Electro-technics and electro-chemistry.

Engineering drawing.

Mechanics and workshop practice.

Properties of materials.

Elementary chemical engineering.

Construction of works.

Fuels, lubricants; technical analysis.

B. *Business administration and economics.*

Business initiation.

Industrial administration.

Chemical economics and costing.

Economics and industrial relationship.

Sociology and industrial psychology.

C. *German.*

The object is that the student should know the principles that are followed in the design, construction, lay-out and working of processes and plants, that he should know something of economics and of business administration with a view to the initiation, maintenance and development of industries and that he should be able to understand the people with whom he must work from the labourer upwards. The student should be required to produce evidence of having taken the courses in the required subjects that are prescribed although he need not reach the same standard in them as in the Fundamental subjects.

50. ELECTIVE SUBJECTS.—The student, while studying the Fundamental and Required subjects in the second year of his training, is introduced to the subject or subjects selected by him for specialisation in the third year. The courses of study in the second year are adjusted accordingly. Professor Cobb explained this at the Conference, on “the place of applied chemistry in the training of chemists”, that was held in 1925 under the

auspices of the Institute of Chemistry in these words: "During the second year, he takes chemistry, inorganic and physical, and engineering and begins on his more special departmental work, *i.e.*, he begins to receive an introduction to the special subject selected... in which he is to take advanced courses in the third year." Moreover, not only should the student be introduced in the second year to the Elective subject that he will study intensively in the third year but the work on Required subjects can be distributed over all the three years of the course, as is found to be convenient. The Elective subjects that we propose are three in number of which the student is expected to take up only one.

ELECTIVE SUBJECTS.

- I. Chemical Engineering.
- II. Textile Chemistry.
- III. Industrial Chemistry.

51. THE ELABORATION OF THE SCHEME:—As regards the subjects of study, we repeat that work on the Fundamental subjects must needs come first, that the Elective subject will be studied intensively in the third year and that the Required subjects which may be prescribed must be spread in an appropriate way over the three years of the course. We insist on the need for thorough study of the Fundamental subjects. But we refrain from deciding on numerous technical details. We later recommend that the University should take early steps to appoint a committee and an executive officer to elaborate our scheme. We hold that it would be advantageous for the University to consult, on the details of the scheme, bodies such as the Institute of Chemistry, the Institution of Chemical Engineers and the Massachusetts Institute of Technology. The training that will be given in the

Department could thus be placed on lines that should satisfy both the University and the public.

SECTION 2. CHEMICAL ENGINEERING.

52. Chemical Engineering has become a separate branch of learning at leading universities and other institutions in the West. Because it is a recent addition to the older branches of engineering, what is essential to the training of a chemical engineer cannot be widely known. Detailed information not being readily available the Committee quotes in full "the outline of subjects special to the training of a chemical engineer" prepared by the Institution of Chemical Engineers.

"A. CHEMICAL ENGINEERING PROCESSES :—

I. CONVEYANCE AND STORAGE OF MATERIALS :

- (a) Methods of measurement of gases and liquids, and the laws governing their flow.
- (b) Plant and equipment for conveyance and storage of solids, semi-fluids, liquids and gases.

II. PRODUCTION, TRANSFERENCE AND CONSERVATION OF HEAT (including instruments employed for the chief measurements).

(a) Combustion.

1. Fuels: Calorific value and intensity, properties and analysis.
2. Furnaces: General principles of design of important types and accessories.
3. Control of furnaces: Measurement of temperature and draught and analysis of flue gases.

(b) Refrigeration.

(c) Heat exchangers, coolers, heaters, etc.

III. TREATMENT OF MATERIALS :

(a) The physical, physico-chemical and engineering principles governing the design, lay-out and operation of plant, for the processes employed in chemical industry;

(b) A knowledge of plant for some of the typical operations in the physical and reaction treatment of materials selected from the following:—

1. Size Reduction.

2. Mixing and Agitation.

3. Separation *without* change of phase or physical state:

i. Electrical and Magnetic Separation,

ii. Hydraulic Separation.

iii. Air Separation.

iv. Flotation.

v. Settling.

vi. Filtration.

vii. Centrifuging.

4. Separation *with* change of phase or physical state:

i. Leaching and extraction.

ii. Evaporation.

iii. Distillation and condensation.

iv. Drying.

v. Crystallisation.

vi Absorption and Adsorption.

5. Reaction Treatment :

- i. Roasting and Calcining.
- ii. Destructive Distillation.
- iii. Electrolysis.
- iv. Catalysis.
- v. Hydrolysis.
- vi. Fermentation.

(c) The preparation of quantitative Flow Sheets of material, energy and time, and their relation to plant design.

B. CHEMICAL PLANT CONSTRUCTION :—

- I. The nature and properties of the more important materials employed in the construction and erection of plant.
- II. The resistance of materials of construction to corrosion and to chemical and physical change.
- III. The principles involved in the design and construction of plant.

C. FACTORY DESIGN AND CONSTRUCTION :—

- I. LAYOUT AND CONSTRUCTION :
 - (a) Buildings, including foundations; materials and principles of design.
 - (b) Communications, Railways, Roads, etc.
- II. POWER, HEAT AND LIGHT :
 - (a) GENERATION.
 - 1. Steam : General principles of construction and control, and determination of efficiency of boiler installations and steam operated plant.

2. Electricity : Types of generators, transformers and motors ; lighting systems; cables, switchboards and fuses.
3. Power Gas : Types of generators, producer and water gas plant ; gas and oil engines; calorific value and intensity and analysis of gas.
4. Air: Types of compressors and accessories.

(b) TRANSMISSION.

1. Steam : Layout and erection of pipe lines, traps and fittings.
2. Electricity : Installation and care of cables and accessories for power and light.
3. Power Gas : General principles of distribution.
4. Compressed Air : Distribution.

(c) Economics of Power Generation and Transmission.

(d) Special precautions required in connection with plant in chemical works.

D. INDUSTRIAL ECONOMICS :

I. General principles of Factory Organisation and Management.

- (a) Factory records, including costing and flow sheets.
- (b) Preparation of specifications, designs and estimates.
- (c) Preparation of reports.
- (d) Compilation and indexing of technical information."

53. CHEMICAL ENGINEERING : TWO METHODS OF TRAINING.—Two methods of training can be used in chemical engineering, namely, the “unit plant” and the “unit operation” method. The first requires the provision of a complete set or sets of the equipment required for the production of a commodity or commodities. The result is a number of small scale factories where a student gains knowledge of the machinery used in an industry and can practise the routine of that industry. But the tendency now, in leading institutions, is to replace the “unit plant” method of instruction by what is known as the “unit process” or “unit operation” method. What this means is explained in a report that was made in 1915 to the President of the Massachusetts Institute of Technology and which said :—“Any chemical process, on whatever scale conducted, may be resolved into a co-ordinate series of what may be termed “unit operations”, as pulverising, drying, roasting, crystallising, filtering, evaporation, electrolyzing, and so on. The number of these basic unit operations is not large and relatively few of them are involved in any particular process. The complexity of chemical engineering results from the variety of conditions as to temperature, pressure, etc., under which the unit operations must be carried out in different processes, and from the limitations as to materials of construction and design of apparatus imposed by the physical and chemical character of the reacting substances.” After detailed study of these “unit operations” the student co-ordinates his knowledge and practice by designing the plant required for the manufacture of a specified commodity. This training, fortified by experience, produces a man of technical judgment who can decide how to modify and to develop, and when to discard, the plant used in an industry.

54. THE "UNIT OPERATION" METHOD: TWO CONSEQUENCES.—There are two important consequences of employing the unit operation method in chemical engineering. One is that an industry is not neglected, although the plant, in miniature, that it requires is not set up permanently in the laboratory: all the operations used in that industry are studied. The other consequence is that a special teacher has not to be provided for each industry that is taken into consideration. The student, by the time he is studying chemical engineering, should be intellectually competent to specialise in a selected minor industry under general guidance.

SECTION 3. TEXTILE CHEMISTRY

55. THE TEXTILE INDUSTRY IN BOMBAY.—In Bombay, as in Manchester, the cotton textile industry is of premier importance. At the Conference of 1925, Professor Hübner said, with reference to the Manchester Municipal College of Technology, "We must take notice of the requirements of this industry.....If in a three years' degree course in Manchester we do not mention one single word about cotton we should quickly get into difficulties. After all is said and done, we are expected to turn out students who will ultimately secure places in the industry and I think we are fulfilling that expectation at present." Thus, in any department of chemical technology that the University of Bombay may establish, it is obligatory to make provision for textile chemistry.

56. SCHEME FOR TEXTILE CHEMISTRY.—This Committee was informed, by some of its members, that a scheme for a department of textile chemistry had been prepared by the Advisory Committee, the Royal Institute of

Science. On request, we were favoured by the Advisory Committee with a copy of the scheme. This scheme for textile chemistry, with proper adaptations, is absorbed in our proposals. It had been drawn up in consultation with managers of mills and dyeing masters in Bombay, with the benefit of comments from Professor Rowe, of Leeds University, and with the assistance of two leading firms, one English and the other Continental. By combining this scheme with other proposals for chemical technology, we find that it is possible to effect economy in equipment and in staff. The Advisory Committee foresaw the need for consideration of the scheme for textile chemistry in conjunction with the scheme for a department of chemical technology.

57. The Advisory Committee recommended the establishment of a department of textile chemistry with a view to meeting the requirements of the cotton-mill industry in India. At present there is no institution in this country of university standard that gives instruction in textile chemistry.

The Advisory Committee assumes that the department of textile chemistry would be located at the Royal Institute of Science. The ground floor of the east wing (the Sir Cowasji Jehangir building) was found to be sufficient in area for most of the heavy plant that is required. It is assumed also that the Royal Institute of Science, as a teaching institution, would co-operate with the department of textile chemistry.

Students would be prepared in the department of textile chemistry for a degree in technology under the University. The course for the degree is to take three

years. Applicants for admission to the course must have passed the Intermediate Science examination in mathematics, physics and chemistry.

All students of textile chemistry take the same work in the first and second years of the course. In the third year a student takes both (a) bleaching, dyeing and printing and (b) sizing and finishing, and gives special attention either to (a) or (b).

The maximum number of students in the department is fixed at 60, that is, 20 fresh students are to be admitted each year.

The Advisory Committee recommends that "the Department of Textile Chemistry should be available to the public for consultation work. Fees would be charged and be distributed, under a standard method, between the Department and the officers concerned."

SECTION 4. INDUSTRIAL CHEMISTRY.

58. Consideration of the Holland Commission Report, of the proceedings of industrial conferences and of recent activities in the promotion of Swadeshi goods, proves that it is urgent for the University to provide training in chemical technology. Each of the Elective subjects that we propose has its value for the purpose. Chemical Engineering is essential for all chemical industries. Textile chemistry must mean, in Bombay, cotton textiles first and foremost. With a view to including Industrial Chemistry as an Elective subject a list is given at the end of this section. That list is based on a careful study of the growing industries of India, and especially of the Bombay Presidency. It is true that the large scale operations which are carried on in western

countries are not often undertaken in India. Nevertheless, one way or another, India has made a beginning with most of the industries specified in the list: these are to be developed and the remainder must be initiated. In organising the Department, certain subjects will be chosen from the list, as being the most suitable for treatment. The student taking industrial chemistry will make a general study of chemical industries and a detailed study of one of the subjects for which the Department may make provision.

LIST UNDER III (INDUSTRIAL CHEMISTRY.)

Alkalies.
 Prewing.
 Canning.
 Cellulose.
 Ceramics.
 Dairy chemistry, including casein products.
 Dyes and intermediates.
 Destructive distillation of coal.
 Destructive distillation of wood.
 Electro-chemical industries.
 Essential oils and perfumery.
 Fertilisers.
 Fine chemicals.
 Foods.
 Foundry practice.
 Fuels.
 Gases.
 Glass.
 Leather and glue.
 Metallurgical industries.
 Mineral oils and lubricants.
 Oils, fats and waxes.

Paints, pigments, gums, varnishes and resins.
Paper.

Pharmaceuticals including alkaloids and drugs.

Photography: photomechanical processes.

Printers' ink and colours.

Pyrotechnics and match manufacture.

Rayon.

Sizing and finishing materials.

Soaps and candles.

Starches.

Sugars.

Sulphuric acid.

Tanning materials.

Technical chemical analysis.

Tobacco industry.

SECTION 5. DEGREE, DIPLOMA AND SPECIAL COURSES.

59. DURATION OF THE DEGREE COURSE.— It should be possible for a student, who completes the course for the degree of B.Sc. Tech., to begin his life of usefulness both to his family and the community at the same age as students trained for other professions. This points to the age of 22 or 23 as the normal age for graduation. Assuming 17 or 18 as the age for matriculation, two years would be required to prepare the student for the Intermediate Science examination in group A (mathematics, physics and chemistry) the passing of which should be one of the conditions for admission to the specialised course for the degree. To the specialised course, therefore, three years may be allotted, giving a total of five years from the date of matriculation. The Institution of Chemical Engineers has given attention to this consideration in the education it proposes for a chemical

engineer: it assumes that a student matriculating at 18 should be able to launch out as a professional junior after about five years of training.

60. ADMISSION.—The Committee recommends that admission to the University Department of Chemical Technology should be determined by the marks obtained by candidates at an Entrance Examination, to be conducted by the University. All applicants for admission should be required to appear at this examination. No preference should be given to graduates in science and no age limit should be fixed. Permission to appear at this examination should be restricted to those who have passed the Intermediate Science examination in the group, mathematics, physics and chemistry or the B.A. Honours examination in the group, physics and chemistry, together with mathematics as a subject at the Intermediate Arts examination. The subjects of examination need not go beyond the syllabus of the Intermediate Science examination and the standard of attainment required would be high. In making this recommendation the Committee is influenced by the consideration that the limited resources of the University must be spent to full advantage and that this aim can be secured by a rigid selection of students best fitted to obtain benefit from the courses of the proposed department.

61. EXEMPTIONS.—The Committee recommends that all students obtaining admission should take the full three years' course for the degree and that, as a rule, no exemption should be granted from attendance at lectures on the ground of an applicant having attended similar courses in other institutions. In particular cases, however, the Director at his discretion may exempt such

students from attendance at lectures or practical work in minor subjects. The students obtaining such exemptions, however, would be required to appear at all examinations of the class to which he belongs.

62. EXAMINATIONS.—The University Department of Chemical Technology will be in a peculiarly favourable position to examine its own students. The examinations of the Department will be the University examinations.

For the degree examination it is recommended that external examiners should be associated with the teachers of the Department.

The Committee recommends that, in the first two years of the course, class examinations should be held at comparatively frequent intervals as a test or appreciation of the student's progress, especially on the theoretical sides of the subjects of instruction. Frequent examinations of this kind act as an inducement to regular study and to accuracy in expression, and relieve the strain associated with heavy terminal examinations.

In the final year of the course the Committee recommends that more emphasis should be laid on tutorial methods than on lectures and class examinations.

Promotion from one class to another and admission to the degree examination would depend on the results of these class examinations and the reports of the teachers.

Rigid tests should be applied in order to ascertain whether a student is fit or not to proceed from the work of one year to that of the next.

63. STATUS OF DEGREES.—The University Department of Chemical Technology should prepare students for the degrees of B.Sc. Tech., M.Sc. Tech., and D.Sc. Each degree will be distinctive of the ordinary or higher qualifications of the holder and of his place in professional life. Chartered institutions for professional occupations place their members in three classes, students, associates and fellows. The grade of an associate is indicative of training and not of mature experience, nor of reliability and dependability for responsible position. The holders of the degree B.Sc. Tech., will be classified with such associates. The degree of M.Sc. Tech., involving research work, will correspond to the fellowship of an institute where advanced study combined with experience or research are the distinguishing features. The doctorate will be reserved for men of mature experience, high distinction and achievement.

64. DIPLOMA AND SPECIAL COURSES.—It is now recognised that the cause of industrial education is strengthened by the provision of diploma or part-time courses and of special courses in special subjects without the rigid conditions required for the degree course. This provision does not require additions to the building, laboratories and equipment and is a source of additional revenue. A committee of the Academic Council is working at a scheme for diplomas to be given by the University. Such courses are meant for the betterment of men already engaged in industries who have been denied by force of circumstances the benefits of modern education in highly equipped institutions. There is always a number of men eager to improve their position by study in their spare time and there are always employers who, in the interests of general efficiency and

the improvement of processes, are willing to give facilities to their employees to obtain further training. The association of these workers with the regular students is a benefit to both. Such association has often resulted in opportunities being found in works for the degree student. Diploma and part-time courses, however, should be arranged only after the degree courses are fully provided for. They would sometimes take the form of evening classes where instruction in individual subjects would be given.

It may be possible in course of time, as the development of evening classes proceeds, for students, who have passed the Intermediate Science examination, to attend these classes and satisfy all the requirements for the degree of Bachelor of Science in Technology.

65. **PROGRESS COURSES.**—The Committee also recommends that the example of similar institutions in offering facilities to their graduates should be followed. Men engaged in industry who have had excellent university training find it difficult to keep abreast of the times in their knowledge of theory. Progress Courses and short courses devoted to advances in theory and practice in different subjects give such men the opportunity of freshening their outlook.

66. It will be a gain to the cause of technological education if the University takes early steps to establish a faculty of technology, which faculty would elect the board of studies required for the purposes of this Department.

CHAPTER IV

COST AND ADMINISTRATION.

SECTION 1. ACCOMMODATION AND ABSORPTION.

67. The Committee on University Reform, after satisfying itself that there is a demand for university trained students, suggested that not more than 200 students, at first, should be admitted to the proposed college of technology. We propose to limit the admissions to the Department of Chemical Technology, which is one part of their scheme, to 120 as a maximum, that is, to 40 per year. This limitation is forced upon us by considerations other than financial stringency. The primary consideration with us is the absorption in industry of trained students after graduation. When the Holland Commission and the Thorpe Committee made their recommendations, it was felt that there was a demand in various industries for students trained in applied chemistry. Our proposals for the University Department of Chemical Technology are based on the belief that chemical industries are growing in India and that they present increasing opportunities for the absorption of Indian graduates in responsible positions. In many western countries industrial professions under existing economic conditions appear to have reached saturation point for the time being, in much the same manner as the legal and medical professions have in this country. Industrial development in India is, however, in its infancy and there is no doubt that the intense desire for Swadeshi undertakings will accelerate this development. The right type of trained man must be forthcoming. This development, if it proceeds on proper lines, will tend to produce a better balance in the national life and the professions.

68. The Committee believes that opportunities will multiply and that the demand for the right type of graduate will increase faster than the supply. What Henry Ford said of the earlier phase of American industrial development is true of present conditions in India. "The fact is that a generation ago there were a thousand men to every opportunity while to-day there are a thousand opportunities for every man. Affairs in this country have changed just that much. However, when industry was growing up, opportunities were limited. Men saw along one track and all of them wanted to get on that one track. Naturally some of them were shoved off; there were more men than opportunities. That is why we had so much fierceness and cruelty of competition in the old days. There were not enough of the big opportunities to go around. But, with the maturing of industry, a whole new world of opportunity opened up. Think how many doors of creative activity every industrial advance has opened. It has turned out through all the fierce competitive fights that no man could succeed in his own opportunity without creating many times more opportunities than he could begin to grasp."

69. The students who graduate from the University Department of Chemical Technology will not all have specialised in the same subject. The Committee believes that industry will be able to absorb every year at least 15 to 20 men trained in the Department. The Committee is strengthened in this belief by a study of the statistics for India (as given in appendix F) showing the various kinds of industries and the number of responsible positions provided therein. It is with this number in view, the Committee recommends that provision be made for

a total of 120 students, about 40 students being admitted annually. In planning the laboratories a maximum of 120 students has been assumed.

70. In arriving at these figures the Committee has kept in view the experience of technological colleges elsewhere. The Society for the Promotion of Engineering Education some years ago instituted an exhaustive enquiry into the number of students who take up and who complete specialised training: of each 100 entering students, 62 successfully complete the first year, and only 42 complete the first two years. The others drop out for one reason or another, the predominant reason being scholastic failure.

SECTION 2. BUILDINGS AND GENERAL EQUIPMENT.

71. BUILDINGS.—The Sir Cowasji Jehangir Building, (Plate II), which is the east wing of the Royal Institute of Science, will be available for the purposes of the Department of Chemical Technology if Government and the donor agree to our proposals. The three floors of this wing, each having floor space, the verandah excluded, of 31 feet by 157 feet; or 4867 sq. ft., will be sufficient for the general laboratories and dye-house but insufficient for the remainder of the Department as outlined in our scheme. We therefore propose that an additional building be constructed on the chord of the crescent. The size of the proposed extension has been carefully thought out. It provides the minimum space required for the housing of the laboratories not accommodated in the east wing. With the growth of the activities of the Department, the wing on the chord of the crescent may be completed (Plate I). The building proposed at present is 131 feet long; it will have three floors. In certain places

the walls will have to be strengthened and the beams and joists will have to be spaced so as to accommodate the heavy equipment in the chemical engineering department.

72. The additional wing will create a quadrangle: no structure is proposed to be erected in the open space between the Royal Institute of Science and the wing. The main library may be housed in the Sir VasANJI Tricumji Mulji Library of the Royal Institute of Science: provision has been made for a reference library.

73. GENERAL EQUIPMENT.—The general equipment should include—

- i. lighting and ventilation;
- ii. steam and distilled water;
- iii. high pressure water line;
- iv. high pressure gas line;
- v. compressed air line;
- vi. vacuum line; and
- vii. low and high tension electric lines.

SECTION 3. LECTURE ROOMS, LABORATORIES AND EQUIPMENT.

74. LABORATORIES:—The proposals for the laboratories have been worked out subject to the limitation imposed by financial necessity and in view of the intention to extend the department later. Provision has been made for important branches of applied physics and chemistry, metallurgy excepted. These laboratories are placed on floor B of the east wing. On the floor above (floor C) special accommodation is provided for the industrial applications of organic and inorganic chemistry. The ground floor of the same building is reserved for textile

chemistry (dyeing, bleaching and finishing). The sector between the east wing and the new wing can be used for administration and general purposes on floors C and B: on floor A a dyeing laboratory and a lecture room are provided.

75. PROVISIONAL LAYOUT.—The following description and location of rooms and laboratories indicates what can be done with the available space, and can be used in preparing estimates of the cost of fittings. The arrangement that is shown may need revision by the authorities in consultation with the Director of the Department.

FLOOR A.

1. DYEING, BLEACHING AND PRINTING :

Plant and machinery will be laid out for giving practical training to the student on a semi-works' scale.

2. LECTURE ROOM:

This room will be fitted up for lectures in organic chemistry, dyestuffs, dyeing and the chemistry of fibres.

3. DYEING LABORATORY:

This laboratory is meant for experimental work on the properties and use of various classes of dyes, properties of intermediates, sizing materials and generally for technical tests and works' analysis required in the processes of bleaching, dyeing, printing, sizing and finishing.

4. BOILER HOUSE:

The boiler house will be furnished with an oil-fired, high pressure steam boiler and will contain such auxiliaries for demonstration purposes as will enable the

student to understand the working of steam power plant. The boiler will supply steam to the distilled water plant, the Dyehouse, the Chemical Engineering Laboratory, and generally wherever required.

5. BLEACHING AND DYEING :

This room will be fitted up with high pressure kier, washing and scouring vats and dyeing jiggers.

6. ELECTRO-CHEMICAL LABORATORY :

This room will be furnished with electrolytic cells, storage batteries, electroplating vats and similar apparatus required for electro-chemical work.

7. WORKSHOP :

This will contain lathes for wood and metal work for the preparation of patterns and appliances for the repair and maintenance of plant and instruments. It will be in charge of a mechanic and fitter. In this room demonstrations may be given to the students in workshop practice. It is possible that the workshop of the Royal Institute of Science may be available for the Department and this room may then be used as an engineering laboratory or for storage of materials.

FLOOR B.

8. ANALYTICAL AND GENERAL INORGANIC LABORATORY :

This laboratory is to be fitted up for general analytical work in inorganic chemistry. The working tables will be of the heavy type, resting on shock-absorbing pads, and be fitted with cupboards and drawers. The floor area of this laboratory is about 1200 sq. ft., allowing accommodation for about 40 students.

9. BALANCE ROOM AND REFERENCE LIBRARY :

Adjoining the above laboratory is the balance room equipped with balances. It will also contain reference books and provide for writing notes and journals.

10. GENERAL ORGANIC LABORATORY :

Accommodation will be provided in this laboratory for 20 students only, giving to each student double the space that is provided in the Analytical and General Inorganic Laboratory.

11. PHYSICAL CHEMISTRY LABORATORY :

This laboratory will be used only for advanced study and special work in physical chemistry.

12. ELECTRO-TECHNICS LABORATORY :

This laboratory will be equipped for Electro-technics and will also be used for general physical work.

13. CURATOR'S ROOM :

The laboratories are laid out on the principle that there should be a central place where instruments and special apparatus will be kept by a Curator with a view to their proper maintenance. The Curator will issue the apparatus to the laboratories if and when required.

14. SPECIAL LABORATORIES :

This laboratory (and three others) will be reserved for researches on chemical problems, including such as may be confidential.

FLOOR C.

15. INDUSTRIAL CHEMICAL LABORATORY :

This laboratory will be equipped with facilities for carrying out work for selected industries.

16. BALANCE ROOM :

17. SPECIAL LABORATORY :

18. HIGH TEMPERATURE ROOM :

This room will be equipped with ovens and furnaces of various kinds for ultimate analysis, high temperature work, etc.

19. GAS AND WATER ANALYSIS :

This laboratory will be used for gas, fuel and water analysis, etc.

20. PHOTOGRAPHY :

This room will provide facilities for projection and microphotography and spectro-photography.

21. DRAWING OFFICE:

This room will be equipped for general instruction in machine drawing, designing and advanced draughtsmanship and be furnished with small scale wooden models.

22. LECTURE ROOMS :

As there is no separate museum provided for models of engineering plant, etc., the two lecture rooms will be furnished with specimen cupboards.

23. TWO SPECIAL LABORATORIES:

24. CHEMICAL ENGINEERING LABORATORY :

This laboratory will be used for work on the unit operation basis. It will be equipped with the plant required for grinding, sifting, dressing and general handling of solids : also with pumps of various types for liquids, plant for evaporation and distillation, drying and scrubbing of gases, blowers, compressors, vacuum pumps and generally such machinery as will familiarise the student with the fundamentals of chemical engineering.

The laboratory is located on the second floor because some of the plant will extend to the first floor and even to the ground floor; for purposes of vacuum evaporation a barometric height has to be provided. There will be a service lift near the chemical engineering laboratory. On the roof of this laboratory, tanks for water will be installed having a storage capacity sufficient for the laboratories and boiler. Small laboratories will be placed on the roof for such work as the drying of printed and dyed materials and the testing of dyes in sunlight.

76. GENERAL APPARATUS.—The apparatus provided should be selected with a view to making—

- (a) provision for carrying out the courses in the Fundamental and Required subjects; and
- (b) provision for work in selected chemical industries.

All the equipment should be chosen with a view to its general usefulness and adaptability. Then, if a special problem which has arisen in an industry should be brought to the Department for solution, there would be a reasonable probability of its being treated without loss of time. A list of apparatus which can be taken as suggestive is given in Appendix E. The selection must be left to an equipment board. It is believed that adequate equipment can be obtained by the expenditure of £8000 to £9000.

77. CHEMICAL ENGINEERING EQUIPMENT.—A chemical engineering laboratory has been provided for carrying out experiments mainly on the unit operation method. The equipment and apparatus required for this laboratory are estimated to cost Rs. 35,000 and will be selected from the list in Appendix E.

78. DYE-HOUSE EQUIPMENT.—By experience in a cotton mill, or a dye-house, a man can become skilled in finishing or dyeing cotton. But the work in a cotton mill, or a dye-house, which has its special markets in view, tends to be limited to what meets the requirements of those markets. In order that the student can be trained in a wide range of work we propose to provide opportunities for the study of the different styles and types of printing and dyeing, as follows:—

1. Grey Room and Singe House.
2. Bleach House containing high pressure kier, slack washing machine, squeezing and piling machine.
3. Mercerising range consisting of mangle, stentering machine, squeezing and plaiting machine, scutcher and water mangle.
4. Dyeing machinery consisting of jiggers and a padding mangle.
5. Finishing machinery consisting of starch mangle, mixing tubs, starching and drying machinery, stentering machine, heating arrangement, blowing fan, damping machine, frictioning and finishing calender, beetle and plaiting machine.
6. Yarn dyeing machinery including hand dye beck hydro extractors, mordanting and sizing machine, cheese dyeing and dyeing cylinder and drying stoves.
7. Electrolytic, bleach plant.
8. Printing machinery including shearing machine colour pans, printing machine, ageing machine

steaming cottage, soaping machine, starching machine, drying machine and back starching machine.

9. Aerograph spray printing plant.

79. EQUIPMENT.—A board of equipment should draw up the list of equipment in textile chemistry so as to entail expenditure not exceeding Rs. 1.5 lakhs. We conclude, from the estimates obtained by the Advisory Committee of the Royal Institute of Science, that the department of textile chemistry can be well equipped for this amount.

80. GIFTS TO THE DEPARTMENT.—Many colleges of technology have received special apparatus and plant as gifts from the manufacturers. The Council of the Department may obtain some part of the equipment in this way with a consequent saving in expenditure. For the present purpose it is assumed that all the equipment will be paid for.

SECTION 4. STAFF.

81. The selection of the staff, and above all of the director, is a matter of fundamental importance. The Committee accepts the view, expressed in a communication from Prof. F. M. Rowe of Leeds, that “the success of the scheme depends on obtaining the best possible staff and on the way in which they interpret the different parts of the syllabus. It is more important that the students should be taught the fundamental principles of technical subjects in laboratories than that they should become experts in the manipulation of all the different machinery in the equipment.”

82. The Committee holds that the Director of the Department of Chemical Technology should be a man possessing industrial experience and high technological qualifications. If a qualified Indian cannot be obtained for the post, the Director should be obtained from abroad and should be appointed for a term of five years. During this term, with a view to filling his place at the end, steps should be taken to train two assistant professors so that at least one of them may reach the required level in qualifications and experience.

Our colleague, Mr. Kapilram H. Vakil, is of opinion that competent Indians with the necessary qualifications are available to fill the post with credit and that an Indian should be appointed to the post from the start.

83. With a view to determine the number of teachers and the amount of work to be allotted to them, a study has been made of the practice in similar institutions elsewhere. In routine teaching, the number of hours per week during which the lecturers are engaged is about 25, but where courses are given that entail special preparation, the number of hours devoted to teaching and demonstration is reduced to 16 per week at most. The final allocation of the duties of each Professor and Lecturer is left to the Director and the Council. The following list is to be taken as an indication of what staff is needed for the efficient working of the Department:—

A Director, 3 Assistant Professors, 7 Lecturers, 10 Demonstrators and 3 Assistant Demonstrators. They are assigned duties as follows:—

Department (in charge of the Director or an Assistant Professor).	Subject.	Lecturers.	Demonstrators.	Assistant Demonstrators.
1. Chemistry.	Analytical.		2	2
	Organic.	1	1	
2. Physical Chemistry and Applied Physics.	General Physics.		2	
	Physical Chemistry.	2		
	Spectroscopy and Photography.			1
	Mathematics Mechanics and Electro-technics.	2	1	
3. Chemical Engineering and Industrial Chemistry.			1	
4. Textile Chemistry.	Dyestuffs and Dyeing.		1	
	Dyeing and Printing.	1	1	
	Bleaching and Finishing.	1	1	

In addition, lecturers for German, Sociology and Economics will be needed and also storekeepers, general and administrative staff, mechanics, hamals, etc.

84. The teachers of the technical subjects ought to be men who have had experience in works. Hence the University must offer salaries that will attract and retain competent men even in competition with industry. The following provisional schedule of salaries may be taken as an approximate guide

PROVISIONAL SCHEDULE OF SALARIES.

Members of Staff.	Rates per mensem.			Expenditure in the 3rd year, at the minimum.
	Rs.			Rs.
1 Director ...	1000	50	1500	13,200
3 Assistant Professors	350	25	800	14,400
7 Lecturers ...	200	20	500	20,160
Special Lecturers ...	150			5,400
10 Demonstrators ...	150	10	300	20,400
3 Asst. Demonstrators	100	5	150	3,960
1 Chief Draughtsman	250	15	400	3,360
1 Curator ...	150	10	350	2,400
1 Store Keeper ...	75	2½	100	960
2 Stores Attendants ...	50	2½	80	1,320
1 Boiler man ...	100	2½	150	1,260
1 Fireman ...	50	2½	80	660
1 Mechanic ...	150	2½	175	1,860
1 Mechanic's Asst. ...	50	2½	80	660
1 Head Clerk ...	150	10	200	2,040
1 Clerk ...	100	8	180	1,392
1 General Clerk ...	60	2½	80	780
Menial staff ...		Lump.		5,000
				<hr/>
				98,852
Contingencies				648
				<hr/>
				Total Rs. 99,500

SECTION 5. CAPITAL AND RECURRING EXPENDITURE.

85. ENDOWMENTS AND SOURCES OF INCOME.—Mr. K. M. Munshi informed the Academic Council, in moving the appointment of this Committee, that the University was likely to receive endowments that would meet the capital expenditure on a scheme for chemical technology. The recurring expenditure must needs be met in part by the University, or in whole if assistance from outside is not forthcoming. But a scheme, such as this Committee proposes, that will help the industries of the City and indeed of the whole Presidency, has a strong claim for help on the Bombay Municipality, the Port Trust and other public bodies, on the leaders of industry and on enlightened citizens. The Manchester Municipal College of Technology is controlled and is largely supported by the Manchester City Council. Moreover, in view of the need for trained men in the chemical industries of India, the Government of India should be also requested to contribute to the support of the Department of Chemical Technology.

86. FEES.—The cost of maintenance of the institution per student, according to the estimates (paragraph 91) comes to about Rs. 1,000 per year, and it is suggested provisionally that each student should pay a fee of Rs. 200 for the same period.

87. ESTIMATES —The estimates of the cost of equipment, plant, machinery, apparatus, fittings, etc., are based on prices and quotations obtained from manufacturers and they take into account freight and erection charges. In the case of the principal items the cost has been checked independently and, where found necessary, a margin has been allowed for fluctuations in prices.

Provision is made for all the items of capital and recurring expenditure necessary to bring the scheme into existence and to maintain it in the early stages of operation.

88. **SCHOLARSHIPS AND BURSARIES.**—In the estimate of recurring expenditure, a sum of Rs. 3,000 per annum is provided for scholarships, as a commencement, which may be divided under three heads, viz, junior, senior and research. The more promising students should, after graduation, be helped as far as possible to make further studies in India or abroad. For continuing studies in India, allowances may be provided from a fund created from fees for analytical and other work done for the public and other sundry sources of income which an institution of this nature usually possesses. For further studies in foreign countries, the University might give preference to students of this Department in the award of technical scholarships under the Sir Mangaldas Nathubhai scholarship scheme. It may be possible also by appeals to the public to obtain funds to establish other scholarships for the same purpose.

89. **STUDY LEAVE.**—Study leave for the members of the teaching staff should be considered. The Committee holds that giving such leave would be conducive to the maintenance of the Department at a high standard of efficiency.

90. **CAPITAL EXPENDITURE.**—The capital expenditure required for buildings and equipment is taken at Rs. 6,50,000 as detailed below :—

	Rs.
1. A new wing 131' × 46' × 50' (cost taken at 8 to 10 annas per cubic foot)	1,75,000

2.	Alterations to the east wing (Sir Cowasji Jehangir Building) including wood work for laboratory benches, general fittings, fixtures and furniture	70,000
3.	Gas, electric, water and sanitary fittings	40,000
4.	General apparatus	1,25,000
5.	Equipment and apparatus required for instruction in Chemical Engineering	35,000
6.	Dyeing, printing and bleaching plant including boiler	1,50,000
7.	Applied Science Library including reference books and journals ...	20,000
8.	Contingencies	35,000
	Total Rs.	<u>6,50,000</u>

91. RECURRING EXPENDITURE: The yearly recurring expenditure is estimated as under:—

	Rs.
1. Salaries and wages (<i>vide</i> para 84) ...	99,500
2. Provident Fund, allowances, etc. ...	7,000
3. Gas, water, electric power, stores and chemicals	20,000
4. Repairs and renewals	5,000
5. Scholarships	3,000
6. Library including journals	6,000
7. Office administration— Stationery, printing, telephone, audit, advertisement, postage, telegrams,	

	and all expenses under administration including travelling allowances and visits to works.	...	...	4,000
8.	Contingencies	...	...	500
				<hr/>
			Rs.	1,45,000
	Deduct fees paid by 100 students at Rs. 200 each.	...	...	20 000
				<hr/>
			Rs.	1,25,000
				<hr/>

SECTION 6. ADMINISTRATION.

92. THE COUNCIL.—The Department of Chemical Technology should be controlled by the University through a Council of not more than 20 members, constituted as under:—

Five members appointed by the Syndicate of whom two should be members of the Faculty of Technology when constituted and one a member of the Faculty of Science.

Five members elected by public bodies, such as Chambers of Commerce, the Millowners' Association, the Municipality, the Port Trust and others which have a recognised standing in the commerce and industries of the Bombay Presidency and enjoy the privilege of sending representatives to the Bombay Legislative Council.

Six members nominated by persons who contribute to the expenditure on the Department.

The Director of Industries.

The Principal of the Royal Institute of Science.

The Director of the Department of Chemical Technology.

A member elected by the graduates from the Department of Chemical Technology.

The Council will appoint its own Chairman.

93. EXECUTIVE COMMITTEE.—An Executive Committee should be formed composed of (i) five Councillors, elected by the Council, of whom one should be the Secretary, and (ii) the Director of the Department. The duties of the Executive Committee should be to frame the annual budget, to prepare statements of ways and means of carrying out the objects and programme of the Department and, generally, to maintain its equipment, staff and work in an up-to-date and efficient condition subject to the control of the Council.

CHAPTER V.

GENERAL.

SECTION 1. CO-OPERATION WITH THE PUBLIC.

94. The framing of proposals for the co-ordination of the activities of the Department with the industries of the country presents difficulties because the measures devised or suggested may not arouse a sympathetic response from industrialists. The co-ordination of research institutes with industry has been successful in many instances. But cases are known in which doubts have been expressed or disappointment recorded. The co-ordination of a technological institution with industry is easy, once the institution commands confidence by reason of its organisation, its equipment, and the quality of the staff: it must acquire a reputation. We anticipate that the Department of Chemical Technology will prove itself more and more useful to industry in course of time.

95. We suggest the following measures as indicating the ways in which efforts at co-ordination could be made :-

- (1). The Department should publish the results of its working from time to time in a popular form so that the lay public may appreciate the work done. It should hold periodical conferences and discussions and should arrange scientific exhibitions on industrial subjects in order to arouse, in industrial circles, a practical interest in the Department.

It should maintain a Bureau of Information and Record Office on matters pertaining to industries, which any member of the public might consult on payment of a small fee.

- (2). The Department should arrange with works for visits, demonstrations and practical training for students, and should reciprocate from time to time by giving to members of the works' staff permission to attend special lectures in the Department.

It should keep a register of its old students, follow their progress and regularly seek their assistance in popularising the Department.

It should entrust problems of Chemical Survey to students, as postgraduate work, and publish the results.

It should obtain and give liberal grants to post-graduate students, for studying special problems, connected with the development or initiation of industries, through research work in its laboratories.

- (3). The Department should maintain a register of Works' Chemists and keep in close touch with them and, through them, with chemical industries generally and consider any problems that may be presented by them. It should undertake the study of problems of a fundamental character, thus suggested, in order to lead to the solution of process or operation difficulties.

- (4). The Department should help industrial concerns to obtain trained workers and expert advisers.

Useful results, that have been obtained in the Department in consequence of investigation, should be imparted to any person interested on payment of a reasonable charge as determined by the Council.

It should help industries during their formative years by rendering assistance on technical matters at a small charge.

If any firm wishes to study a problem of a confidential nature through its own investigator, the Department should furnish facilities in a special laboratory in consideration of a reasonable fee as determined by the Council. Such facilities should be granted only to a person who, in the opinion of the Council, is fit to undertake the problem.

- (5). The Department should undertake analytical and consulting work only with the sanction of the Council. The work should be reported without disclosing the name of the worker. Fees should be charged and be distributed, under a standard method, between the Department and the officers concerned,

The Council should preclude every member of the staff from undertaking outside work in his personal capacity, and from receiving fees or gifts from the public for any consultation work, analytical work, research, investigation or other services rendered inside or outside the Department. The Council should preclude every member of the staff from revealing information gained by research if that information is obtained at the expense of a firm. The information, if it has been obtained for a firm by means of an Industrial Fellowship provided by that firm, shall be published only after a number of years as arranged between the firm and the Council. But if the information

has not been acquired by, or assigned to any firm, and if it is of general scientific or industrial interest, the Department may make it known to the public or deal with it as the Council shall determine.

SECTION 2. EARLY START RECOMMENDED.

96. We consider, in these days of mechanisation and rationalisation, when industrial methods and practices are changing so rapidly in Europe and America, that in the interests of the Bombay City and Presidency an early commencement of training in industrial, and especially textile, chemistry is important.

97. The scheme involves the use, at the Royal Institute of Science, of the Sir Cowasji Jehangir Building, of the compound and of the Sir VasANJI Tricumji Mulji Library. Thus for the successful prosecution of the scheme, it is indispensable that the University should receive cordial support from the Government of Bombay.

98. We trust that the University authorities, after satisfying themselves in regard to the financial implications of the scheme, will be able to give administrative sanction to it at a very early date; also that they will take early steps to appoint a small committee and an executive officer, for about six months to begin with, to elaborate the scheme and at the same time to take steps to commence the first year's work of the course for the proposed degree of Bachelor of Science in Technology, in June 1931.

The first year's work can be arranged for without undue difficulty. More than twelve months will be available in which to make arrangements for the work

of the second year commencing in June 1932. It should be possible to construct the new building and complete all the necessary equipment by that time.

99. We would also urge that a Faculty of Technology should be constituted in the University without delay.

100. We would suggest to the University that it is desirable to form a committee, which should include the leaders of industry and technical experts in the Bombay City, to frame a scheme for instruction in other important branches of technology, namely, mechanical engineering, electrical engineering and textile industries, to be taken up in part or in whole as funds become available.

SECTION 3. ACKNOWLEDGMENTS.

101. The Committee held in all thirteen sittings between the 24th July 1930, on which date it began its work, and the 31st December of the same year, when the report was signed. At one stage it sat continuously for six days barring an intervening Sunday.

There has been complete agreement among the members in regard to essentials and the report is unanimous.

102. We have already stated that, at our request, the Vice-Chancellor kindly placed at our disposal a scheme, which had been prepared by the Advisory Committee of the Royal Institute of Science, for a department of textile chemistry and that this scheme is embodied in our proposals.

All the members of the Committee helped with constructive suggestions while the proposals were under discussion and preparation. Mr. Kapilram H. Vakil supplied a wealth of information and prepared the first draft of the scheme, on the lines laid down by the Committee, and Dr. A. N. Meldrum revised the chapters and made valuable suggestions as the work progressed. The Committee wish to record their thanks to these two gentlemen for the ungrudging readiness with which they gave their knowledge, time and labour to this work.

Khan Bahadur Fardunji M. Dastur was present at the earlier meetings and he deputed Mr. S. R. Dongerkery to be present at the later meetings. We are indebted to these officers of the University for facilitating our work in every stage.

M. VISVESVARAYA,—*Chairman.*

A. R. NORMAND.

A. N. MELDRUM.

G. B. KOLHATKER.

K. G. NAIK.

D. D. KANGA.

N. A. F. MOOS.

K. R. KANITKAR.

KAPILRAM H. VAKIL.

H. P. JORDAN.

M. S. PATEL.

BOMBAY,

31st December, 1930.

APPENDIX A

IMPORTS INTO INDIA IN 1928-29.

I. FOOD, DRINK AND TOBACCO:—		Rs.
Fish (excluding canned fish)	... ..	25,76,167
Fruits and vegetables	... ..	1,68,89,888
Grain, pulse and flour	... ..	10,72,80,817
Liquors	... ..	2,94,81,854
Provision and oilman's stores	... ..	6,21,24,467
Spices	... ..	2,94,02,555
Sugar	... ..	16,08,94,988
Tea	... ..	74,22,285
Other food and drink	... ..	1,78,66,669
Tobacco	... ..	2,74,59,528
		<u>Rs. 46,08,48,713</u>
II. RAW MATERIALS AND PRODUCE AND ARTICLES MAINLY UNMANUFACTURED:—		
Coal	... ..	82,96,166
Other non-metallic, mining and quarry products and the like	... ..	1,55,91,314
Fodder, bran and pollards	... ..	1,48,822
Gums, resins and lac	... ..	55,26,481
Hides and skins, raw or undressed	... ..	28,77,477
Metallic ores and scrap iron or steel for re-manufacture	... ..	1,78,668
Oils-vegetable, mineral and animal	... ..	11,58,22,648
Oilcakes of all kinds	... ..	15,918
Paper making materials	... ..	41,50,948
Rubber, raw or crude	... ..	26,884
Seeds, including nuts for oils	... ..	22,18,284
Tallow, stearine, and wax	... ..	26,24,526
Cotton, raw and waste	... ..	8,90,79,187
Jute	... ..	4,672
Silk	... ..	1,28,59,154
Wool	... ..	49,52,846
Other textile materials	... ..	8,18,468
Wood and timber	... ..	59,75,182
Miscellaneous	... ..	1,05,40,819
		<u>Rs. 22,51,98,849</u>

Rs.

III. ARTICLES WHOLLY OR MAINLY MANUFACTURED:—

Apparel	...	...	...	...	2,51,11,251
Arms, ammunition and military stores	...			...	76,64,257
Chemicals, drugs, and medicines	...			...	4,91,50,108
Cutlery, hardware, implements and instruments (excluding electrical instruments and apparatus)	...			...	7,76,92,594
Dyes and colours	...	...		...	4,36,53,785
Electrical goods and apparatus (other than machinery)	...	...		...	3,12,45,414
Furniture, cabinet ware and manufacture of wood and timber	...		...	...	60,68,253
Glass and earthenware	...	...		...	3,11,22,975
Hides and skins, tanned or dressed, and leather					63,98,526
Machinery of all kinds including belting for machinery	...	...		...	19,43,24,230
Metals-iron and steel and manufactures thereof					20,23,49,658
Metals other than iron and steel and manufactures thereof	...		...	...	6,73,60,880
Paper, paste board and stationery	...			...	4,31,54,538
Rubber manufactures	...	...		...	2,85,86,295
Vehicles excluding locomotives etc. for railways					11,00,59,866
Cotton yarn and manufactures	...		...	...	63,24,36,749
Jute	„	...	...	...	26,53,079
Silk	„	...	...	...	3,77,07,473
Woollen	„	...	...	...	4,52,33,720
Other yarns and textiles fabric	...		...	...	6,50,63,047
Miscellaneous, including textiles, jewellery, matches, oil cloth, floor cloth, paraffin wax, polishes, printing, litho and lithographic materials prints and engravings pictures, smoker's requisites, soap, perfumed spirits, starch and farina, toilet requisites, toys, umbrellas, etc.	...	...	...	...	9,59,51,982
				Rs.	<u>180,30,38,680</u>

IV. MISCELLANEOUS, INCLUDING LIVING ANIMALS AND

POSTAL ARTICLES NOT SPECIFIED.	...	Rs.	4,39,72,339
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Grand Total		Rs.	<u>253,30,59,741</u>
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APPENDIX B.

CHEMICALS AND MANURES IMPORTED INTO
INDIA IN 1928-29. (value)

ACIDS:	cwts	Rs.
Acetic (pyroligneous acid) \	3477	1,81,715
Carbolic	1006	87,870
Citric	451	65,440
Nitric	988	84,159
Oxalic	2365	56,133
Sulphuric	4923	62,940
Tartaric	2988	2,72,060
Other sorts:	6207	1,93,447
	22,405	8,58,264
ALUM:	49,800	8,84,386
ALUMINOUS SULPHATES:	71,174	2,79,004
AMMONIA AND SALTS THEREOF:		
Anhydrous	2190	2,46,856
Others	80,680	6,67,874
	82,829	9,14,230
ARSENIC AND ITS OXIDES:	2,558	1,16,055
BLEACHING MATERIALS:		
Bleaching powder chloride of lime.	91,030	5,79,289
Other sorts.	32	714
	91,062	5,80,03
CARBIDE OF CALCIUM:	41,626	46,0,710
COPPERAS (FERROUS SULPHATE):	4,433	19,597
COPPER SULPHATE:-	21,318	4,19,077
DISINFECTANTS:		
Naphthalene	8,948	1,27,103
Others	28,698	8,70,520
	37,646	9,97,623
GLYCERINE:	5,553	2,73,098

LEAD COMPOUNDS:					cwts.	Rs.
Acetate	...	...	...	...	3,719	1,17,256
Litharge	...	...	...	...	729	16,356
Others	...	...	...	...	580	14,972
					<hr/>	
					5,028	1,48,584
<hr/>						
MAGNESIUM COMPOUNDS:						
Chloride	...	...	...	...	29,449	1,16,567
Sulphate	...	...	...	...	38,670	1,29,460
Others	...	...	...	...	4,274	32,000
					<hr/>	
					72,393	2,78,027
<hr/>						
POTASSIUM COMPOUNDS:						
Bichromate	...	...	...	...	5,753	1,55,220
Chlorate	...	...	...	...	34,799	6,22,314
Cyanide	...	...	...	...	358	25,805
Other sorts	...	...	...	...	9,390	5,14,895
					<hr/>	
					50,309	18,18,234
<hr/>						
SODA COMPOUNDS:						
Bicarbonate of soda	...	...	...	...	1,12,648	8,48,793
Bichromate of soda	...	...	...	...	17,935	3,37,486
Borax (including boracic acid )	...	...	...	...	24,503	2,84,445
Caustic soda	...	...	...	...	173,643	19,48,569
Cyanide of sodium	...	...	...	...	11,023	5,41,436
Soda sulphide	...	...	...	...	41,842	2,81,543
Sodium carbonate (soda ash & soda crystals)	...	...	...	...	10,76,634	62,45,427
Sodium silicate:	...	...	...	...	41,911	3,34,634
Other sorts :	...	...	...	...	81,778	5,09,437
					<hr/>	
Total					15,28,917	1,18,31,770
<hr/>						
SULPHUR (BRIMSTONE):	...	...	...	...	3,00,965	15,94,584
<hr/>						
ZINC COMPOUNDS:						
Chloride	...	...	...	...	17,316	2,34,320
Others	...	...	...	...	333	6,626
					<hr/>	
					17,649	2,40,946
<hr/>						
OTHER SORTS OF CHEMICALS :	...	...	...	...		44,54,919
<hr/>						
TOTAL OF CHEMICALS	...	...	...	Rs.		2,47,94,207
<hr/>						

DRUGS AND MEDICINES:				Rs.	
Aloes	...	...	... cwts.	952	22,944
Asafoetida	...	...	... cwts.	3,612	2,08,343
Camphor	...	...	... lbs.	16,12,356	27,79,631
Cocaine	...	...	... ounces	1,259	18,476
Codliver Oil	...	...	... lbs.	90,602	1,30,796
Morphia	...	...	... ounces	1,800	27,782
Preparations of Opium and morphia				1,08,782	
Proprietary and Patent Medicines				42,83,667	
Quinine Salts: lbs. 133,276					
Value Rs. 24,47,075					
Quinine Sulphate or Bisulphate			lbs.	90,592	16,82,535
Quinine Hydrochloride or Bihydrochloride	...	...	lbs.	14,557	4,10,020
Other sorts of Quinine			lbs.	28,127	3,54,520
Saccharin	...	...	lbs.	29,527	1,12,652
Sarsaparilla and preparations thereof				30,876	
Storax, including liquid storax (rose melloes)	...	...	lbs.	1,88,947	56,769
Other sorts of drugs and medicines				99,85,164	
TOTAL OF DRUGS AND MEDICINES ...				Rs.	2,02,12,960
Opium	...	...	lbs.	2,305	53,387
Spirit present in Drugs, Medicines, or Chemicals				...	...
	...	...	gallons	1,51,935	40,89,554
TOTAL OF CHEMICALS, DRUGS AND MEDICINES, OPIUM, AND SPIRIT ...				Rs.	4,91,50,108
MANURES:					
ARTIFICIAL AND MINERAL MANURES:				Tons.	Rs.
Muriate of Potash	...	...		6,364	7,89,743
Nitrate of Soda	...	...		8,840	12,77,812
Sulphate of Ammonia	...	...		17,993	28,53,847
Others	...	...		25,743	21,55,137
Fish manures:	...	...		3,657	3,06,911
Other kinds (excluding oil cake):	...	...		216	23,598
TOTAL OF MANURES				62,813	73,57,048
GRAND TOTAL OF CHEMICALS, DRUGS, MEDICINES AND MANURES ...				Rs.	5,65,07,156

APPENDIX C.

EXPORTS FROM INDIA IN 1928-29.

I. FOOD, DRINK AND TOBACCO :				Rs.
Fish (excluding canned fish)	...	...	...	78,24,082
Fruits and vegetables	...	...	...	96,15,231
Grain, pulse and flour	...	...	...	33,69,42,417
Liquors	...	...	...	1,077
Provision and oilman's stores	...	...	...	64,48,137
Spices	...	...	...	1,58,80,440
Sugar	...	...	...	5,48,062
Tea	...	...	...	26,60,44,198
Other food and drink	...	...	...	1,71,15,779
Tobacco	...	...	...	1,29,47,034
				<u>Rs. 67,33,66,457</u>
II. RAW MATERIALS AND PRODUCE AND ARTICLES MAINLY UNMANUFACTURED:				
Coal	...	...	...	71,32,028
Other non-metallic mining and quarry products and the like	...	...	...	92,44,398
Fodder, bran and pollards	...	...	...	1,44,93,212
Gums, resins and lac	...	...	...	8,86,07,637
Hides and skins, raw or undressed	...	...	...	9,55,97,664
Metallic ores and scrap iron or steel for re-manufacture	..	...	...	2,99,90,545
Oils-vegetable, mineral and animal	...	...	...	86,63,371
Oilcakes of all kinds	...	...	...	3,84,17,955
Paper making materials	...	...	...	1,47,968
Rubber, raw or crude	...	...	...	1,99,85,435
Seeds, including nuts for oils	...	...	...	29,62,51,658
Tallow stearine, and wax	..	...	...	7,97,063
Cotton, raw and waste	...	...	...	66,69,09,888
Jute	...	...	...	32,34,91,538
Silk	...	...	...	27,80,902
Wool	...	...	...	4,88,53,653
Other textile materials	...	...	...	87,56,449
Wood and timber	...	...	...	1,74,89,226
Miscellaneous	...	...	...	2,50,91,065
				<u>Rs. 170,27,01,665</u>

	Rs.
III. ARTICLES WHOLLY OR MAINLY MANUFACTURED;	
Apparel	25,46,642
Arms, ammunition and military stores ...	865
Chemicals, drugs, and medicines ...	2,15,66,185
Cutlery, hardware, implements and instruments (excluding electrical instruments and apparatus) ...	16,89,277
Dyes and colours	1,28,80,004
Electrical goods and apparatus (other than machinery) ... ..	...
Furniture, cabinet ware and manufacture of wood and timber	4,86,181
Glass and earthenware	2,51,611
Hides and skins, tanned or dressed, and leather	9,44,31,718
Machinery of all kinds including belting for machinery	66,101
Metals-iron and steel and manufactures thereof	2,12,96,889
Metals other than iron and steel and manufactures thereof	3,78,16,525
Paper, pasteboard and stationery	1,29,314
Rubber manufactures	13,339
Vehicles excluding locomotives, etc., for railways	20,449
Cotton yarn and manufactures	7,79,55,783
Jute "	56,90,49,215
Silk "	4,86,001
Woollen "	1,02,17,881
Other yarns and textile fabrics	11,95,775
Miscellaneous, including building and engineering materials, candles of all kinds. coke and patent fuel, coir manufactured, excluding rope, cordage and rope of vegetable fibre (excluding jute and cotton), ivory manufactured, jewellery, paraffin wax, perfumery, printing and lithographic materials, soap, toys and requisites, for games and sports, umbrellas etc.	4,88,90,557
	<u>Rs. 89,58,90,322</u>
IV. MISCELLANEOUS, INCLUDING LIVING ANIMALS AND POSTAL ARTICLES NOT SPECIFIED;	
	... 2,93,20,342
Grand Total	<u>Rs. 380,12,78,786</u>

APPENDIX D.

**CHEMICALS AND MANURES EXPORTED
FROM INDIA IN 1928-29.**

	cwts.	Value. Rs.
POTASSIUM COMPOUNDS:		
Saltpetre 	91,972	9,90,308
Other sorts 	59	1,340
	92,031	9,91,648
SODA COMPOUNDS:		
Borax 	1,520	32,688
Other sorts 	178	6,181
	1,698	38,864
OTHER SORTS OF CHEMICALS:	Rs.	6,32,958
TOTAL OF CHEMICALS	Rs.	16,68,465
DRUGS AND MEDICINES:		
Asafoetida Cwts. 	15	2,966
Camphor Lbs. 	2,848	5,175
Cinchona bark " 	138,104	90,874
Galangal Cwts. 	509	10,181
Nux vomica (strychnia) ...	43,212	3,03,208
Senna " 	46,995	8,60,764
Other sorts of drugs and medicines ...		28,87,820
TOTAL OF DRUGS AND MEDICINES	Rs.	41,60,988
OPIUM	Cwts.	4,920 1,57,42,362
TOTAL OF CHEMICALS, DRUGS AND MEDICINES AND OPIUM	Rs.	2,15,66,815

MANURES:	Tons.	Rs.
Bones, crushed	60,893	62,38,479
Bones, uncrushed	183	14,834
Bonemeal	34,171	32,38,372
Fish manures	7,565	8,50,373
Fish guano	1,184	1,98,789
Hornmeal	4,350	5,97,561
Sulphate of ammonia	10	2,050
Other kinds	10,111	10,75,529
		<hr/>
TOTAL OF MANURES	117,967	1,22,15,987
		<hr/>
GRAND TOTAL OF CHEMICALS, DRUGS AND MEDICINES, OPIUM AND MANURES	Rs.	3,37,82,802
		<hr/>

APPENDIX E

EQUIPMENT LIST.

(A selection is to be made from this list, *vide* paragraphs 76 and 77.)

Autoclaves.

Abbé's petroleum tester.

Asphalt testing apparatus.

Anemometers.

Ammeters.

Attemperating tank.

Air lift pumps.

Ball mill.

Balances—all types.

Brinell hardness tester.

Blowers and boosters.

Boiler—gas fired.

Barometers.

Crushers.

Coal analysis apparatus.

Centrifuges.

Colloid filters and mills.

Cathetometers.

Calorimeters.

Conductometric apparatus.

Condensers—all types.

Compressors—high and low pressure.

Combustion furnaces.

Crystallisers.

Crucibles.

Chronometers.

Conveyers.

Dupré's apparatus.
Diaphragm indicators.
Driers- including vacuum.
Digesters.
Distributing panels.
Drilling machine.
Ejectors.
Edge runners.
Electrolysers.
Electrotechnics apparatus.
Electrolytic cells.
Electric furnaces.
Evaporators.
Flash point apparatus.
Furnaces.
Filter presses.
Fabric testing machine.
Filter frames.
Gas absorption plant.
Gas producers.
Granulators.
Gas analysis apparatus.
Gas meters.
Grinding mills.
Grinders.
Gas hoods.
Hydraulic presses.
Homogeniser.
Humidifier.
Incubators.
Jacketted pans.
Kneading and mixing machines.
Kettles.

Lubricant testing apparatus.
Lewis Upton toughness testing machine.
Liquid meters.
Liquid air plant.
Lathes.

Microscopes.
Micrograph.
Menzies' apparatus.
Meteorological instruments.
Manometers.
Mechanical instruments for Applied Mechanics.
Machine tools for wood and metal work.
Molecular weight apparatus.

Ovens—all types.
Oleorefractometers.
Orificemeter.

Pyrometers.
Porcelain ware general.
Polarimeter.
Penetrometer.
Potentiometric apparatus.
Pumps.
Pill forming machine.
Plating vats.
Platinum apparatus.

Quadrants.

Refrigerator.
Recording instruments and valves.
Refractometers.
Rockwell hardness tester.
Resistance cells.
Radiometric apparatus.

- Specific gravity balances and instruments.
- Stills—all types including batch, continuous dephlegmation and rectifying types.
- Spray nozzles.
- Steam traps.
- Stream line filters.
- Stirring apparatus—propeller and other types.
- Sifting machines.
- Spectrometers.
- Shore scleroscope.
- Scales—all types.
- Storage cells.
- Sterilisers.
- Spectrophotometric apparatus.
- Saccharimeters.
- Scrubbers.
- Tablet machine.
- Thermostats.
- Tintometers.
- Thermometers— all types including recording.
- Testing—standard apparatus for water, gas, oils, lubricants and leather.
- Tower packings.
- Uniflow meters.
- Vacuum pumps.
- Viscosimeters.
- Venturimeters.
- Voltmeters.
- Weights and measures standardised by N.P.L.
- Water softening plant.
- Yarn testing machine.
- Zeolite plant.

APPENDIX F.

INDUSTRIES IN INDIA

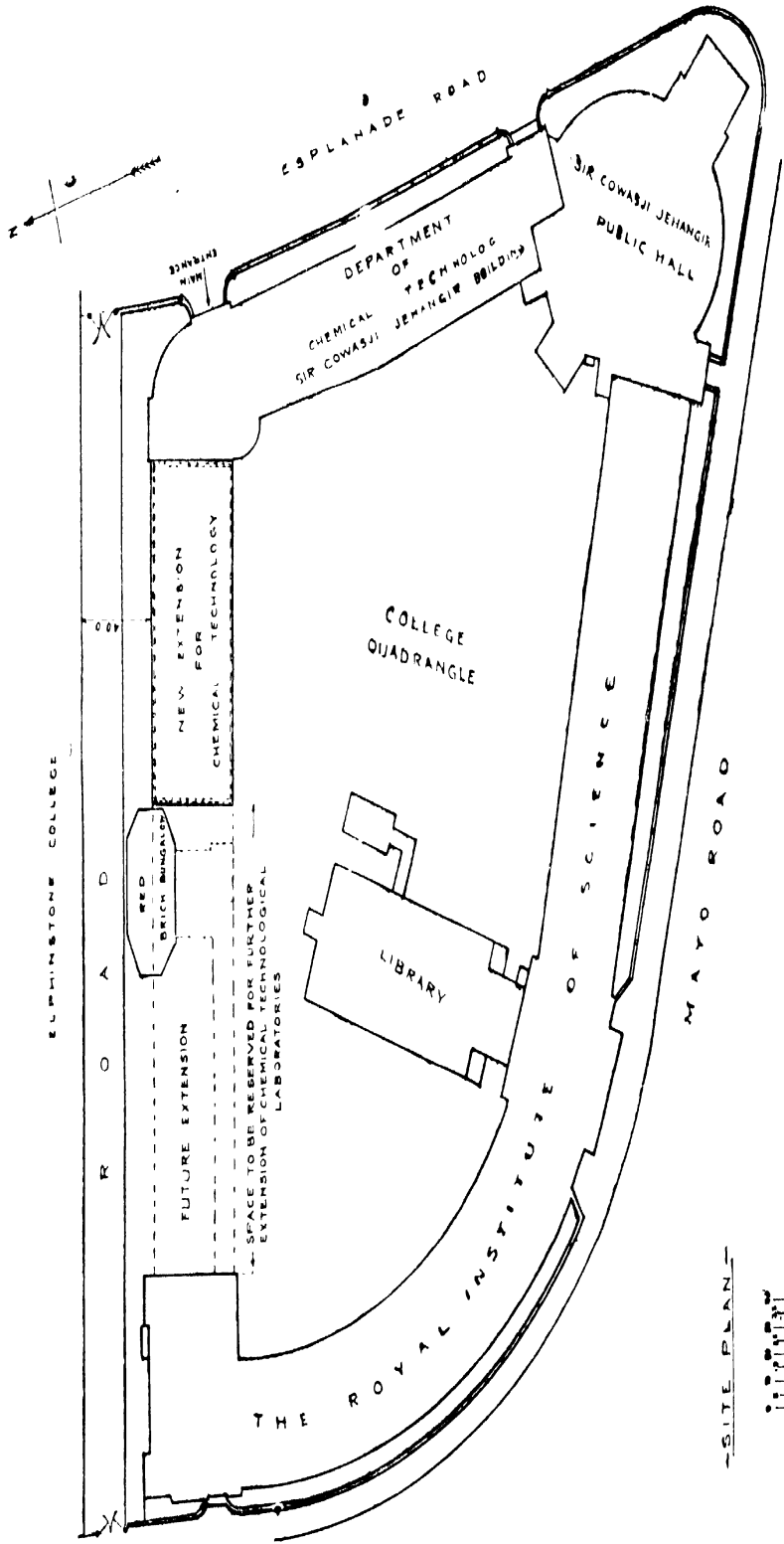
NUMBER OF ESTABLISHMENTS AND EMPLOYEES—1927.

F = Factories.

E = Employees.

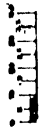
INDUSTRY.	Number of Establishments and Employees.										Approximate Number of Employed, 1921 Census.														
	Bombay Presidency.					British India including Bombay Presidency, 1927.					Indian States Total for the year 1927.			Total (India).			Europeans and Anglo-Indians			Indians.			Total.		
	F		E		F	E		F	E		F	E		F	E		F	E		F	E		F	E	
1	Textiles	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
2	Engineering	127	27,060	539	163,553	68	48,230	26	3,710	565	167,243	485	733,066	2,184	28,033	30,217	...	...	...	...	...	...	...	...	...
3	Minerals and Metals	15	1,084	116	56,169	8	691	8	691	124	56,860	124	56,860	2,054	9,133	11,187	...	...	...	...	...	...	...	...	...
4	Food, Drink and Tobacco	145	4,613	2,745	177,453	68	3,851	68	3,851	6,596	181,304	6,596	181,304	769	11,067	11,836	...	...	...	...	...	...	...	...	...
5	Chemicals, Dyes, etc.	90	15,324	415	47,374	75	6,446	75	6,446	490	53,820	490	53,820	1,149	8,935	10,084	...	...	...	...	...	...	...	...	...
6	Paper and Printing	75	6,475	294	28,515	14	884	14	884	308	29,399	308	29,399	...	...	...	...	...	...	...	...	...	...	...	...
7	Processes relating to Wood, Stone and Glass	23	1,462	352	38,315	95	25,704	95	25,704	447	64,019	447	64,019	272	2,808	3,080	...	...	...	...	...	...	...	...	...
8	Processes connected with Skins and Hides	4	286	32	5,734	4	460	4	460	37	6,194	37	6,194	147	1,332	1,479	...	...	...	...	...	...	...	...	...
9	Gins and Presses.	680	46,625	2,244	178,950	945	42,164	945	42,164	2,889	221,114	2,889	221,114	170	7,398	7,568	...	...	...	...	...	...	...	...	...
10	Miscellaneous (Rope works, Rubber goods, & Misc.)	4	251	51	7,930	38	5,799	38	5,799	89	13,729	89	13,729	...	...	...	...	...	...	...	...	...	...	...	...
	Government Works	56	28,814	310	144,573	48	18,298	48	18,298	358	162,871	358	162,871	...	...	...	...	...	...	...	...	...	...	...	...
	Grand Total of all Industries	1,426	381,868	7515	1,533,382	1,110	156,237	1,110	156,237	8,625	1,639,619	8,625	1,639,619	...	...	...	...	...	...	...	...	...	...	...	...

The first 10 Columns are taken from pp. 662-671 and Columns 11 and 12 from pp. 680-685 of the Government Statistical Abstract for British India from 1918-19 to 1927.

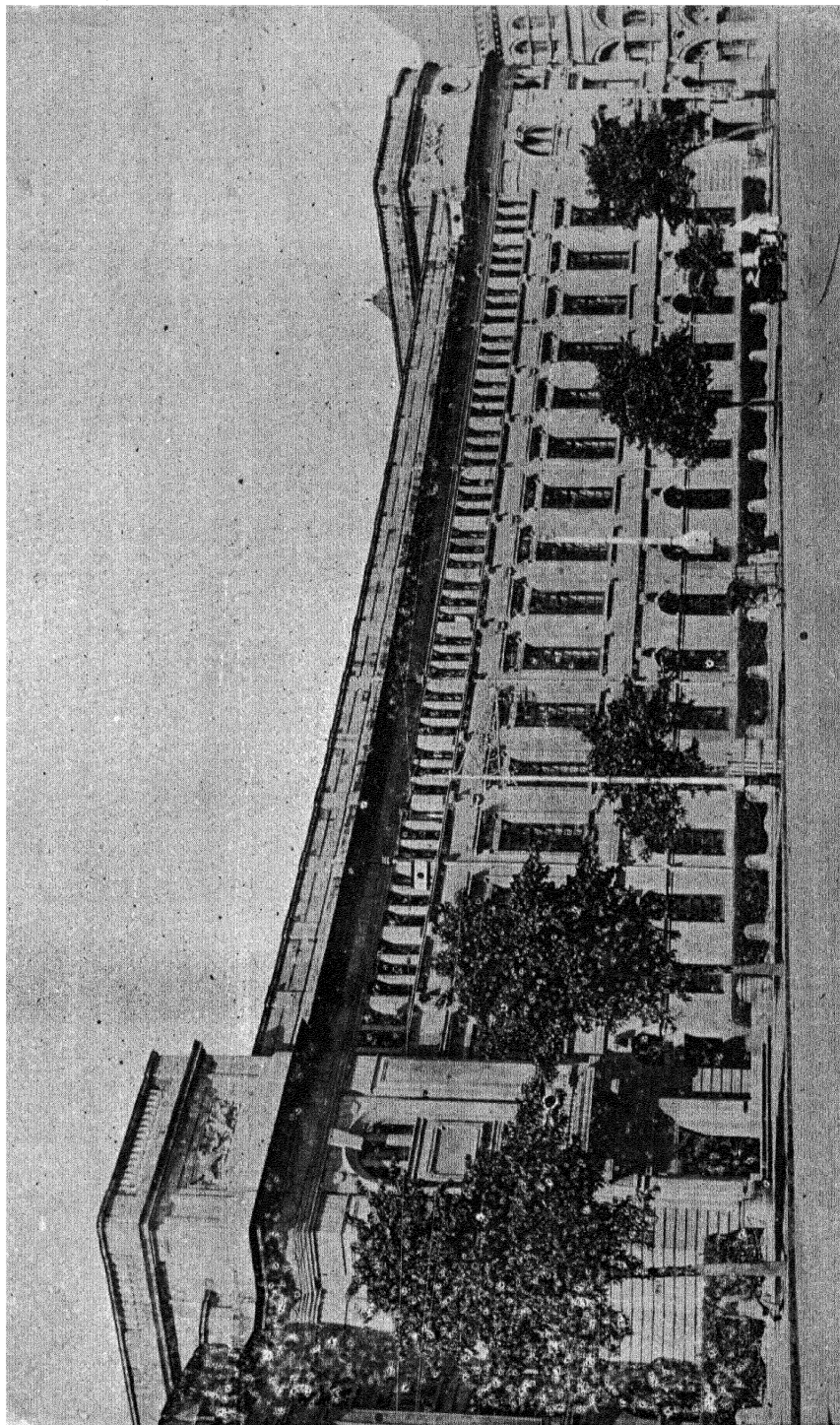


The Royal Institute of Science, Bombay,
Site Plan.

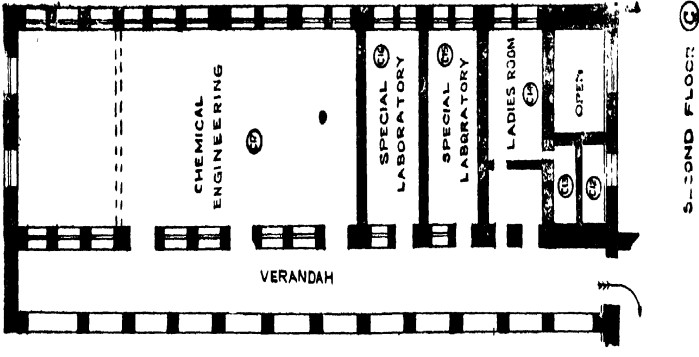
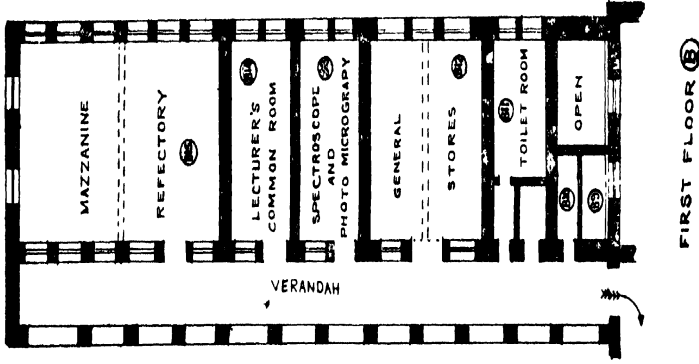
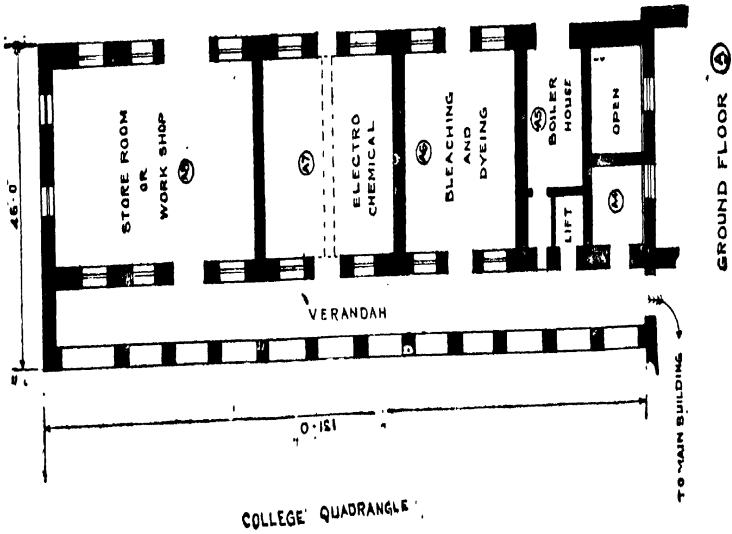
-SITE PLAN-



SCALE



Sir Cowasji Jehangir Building - The Royal Institute of Science, Bombay.



New Wing—Provisional Layout.

