1905.

NEW ZEALAND.

EDUCATION COMMITTEE

(REPORT OF THE) ON SCIENTIFIC AND TECHNICAL EDUCATION; TOGETHER WITH MINUTES OF EVIDENCE.

(Mr. BAUME, Chairman.)

Report brought up 26th October, and ordered to be printed.

ORDER OF REFERENCE.

Extract from the Journals of the House of Represeutatives.

Tuesday, the 4th Day of July, 1905.

Ordered, "That a Committee be appointed to consider all matters relating to education and public instruction generally—school-training of teachers, higher education, technical education, and manual instruction, and for such other matters affecting education as may be referred to it; to have power to call for persons and papers; five to be a quorum: the Committee to consist of Mr. J. Allen, Mr. Baume, Mr. Buchanan, Mr. Buddo, Mr. Ell, Mr. Fisher, Mr. Fowlds, Mr. A. L. D. Fraser, Mr. Graham, Mr. Hall, Mr. Hanan, Mr. Hogg, Mr. Hardy, Mr. Lethbridge, Mr. Lewis, Mr. Major, Mr. Massey, Mr. T. Mackenzie, Mr. McNab, Sir W. R. Russell, Mr. Sidev, Hon. Sir W. J. Steward, Mr. J. C. Thomson, Mr. Wood, and the mover."—(Right Hon. R. J. Seddon.)

REPORT.

THIS paper is a letter to the Board of Governors of the Canterbury College, from the professor in charge, relative to scientific and technical education on the Continent of Europe. (*Vide* Parliamentary Paper E.-15, 1905.)

The Education Committee, to whom was referred by your honourable House the above paper, have the honour to report that they have taken evidence thereon, and that, in their opinion, such evidence should be printed and referred to the Government for consideration.

FRED. E. BAUME,
Chairman.

Parliamentary Buildings, 26th October, 1905.

EVIDENCE.

MONDAY, 4TH SEPTEMBER, 1905.

Professor SCOTT, of Canterbury College, Christchurch, delivered an address on "Some European Technical High Schools."

Mr. Chairman and Gentlemen,—In 1889 and again last year I visited some of the professional and technical schools of Europe. These visits were not made with a view to the preparation of any report on technical education, but rather from a desire to become familiar with modern developments in the theory and method of teaching my own profession. My observations were in consequence more particularly directed to physical and applied science and the various branches of engineering. Much, too, of the information obtained was derived from conversations with friends teaching these subjects, and has therefore no pretentions to statistical accuracy.

In Great Britain there is no generally agreed-upon definite scheme of technical education. It is recognised that the matter is in a transition state, and on the one hand there are many examples of universities undertaking work which should lie within the province of the trade schools, on the other of trade schools adding to their curriculum subjects which can only be properly dealt with in a university college or technical high school.

To a great extent this is due to a sudden realisation that technical training is needed to keep England in her place amongst manufacturing nations. This has given rise to an ardent desire to do something, and that something has differed materially with the personal characteristics and environment of those controlling her educational institutions.

The paucity of our language, too, has perhaps had its influence. We have but one term by which to designate the scientist, who designs and calculates the future performance of the largest undertaking, and the man who slogs a chisel through the bars used in its materialisation—they are both engineers, and apparently it is sometimes thought that the training of both should be similar; but it is only when it is fully realised that the education of the director or designer—the industrial leader—must be of an entirely different order from that of the worker with his hands that it is possible to obtain a satisfactory solution of the problem of "technical education."

The brain worker, it goes almost without saying, should be selected from those who have shown considerable mental capacity, and after receiving a sound education in which especial attention is paid to modern languages, mathematics, and science, should be systematically trained in the application of the latter to his future work. This training it is the function of the technical high school or of the university professional school to supply.

The worker with his hands requires far less preliminary education before he receives instruction on the handicraft of his trade, and in those of the elementary principles underlying his work a knowledge of which will render him the more efficient as a worker. It is the function of the trade school to provide such instruction.

These are practically the views held on the Continent, and although the system adopted may not in all cases be perfect, it is, thanks to State control, an ordered and almost universal one; one, too, which has been in vogue for a considerable number of years and has achieved remarkable success. In Germany, for instance, opinion is almost unanimous in ascribing the present industrial position of the country to the liberal provision made for technical instruction and research. It is to the Continent, therefore, that we must look for the results of a lengthened experience in systematic technical education, and I now propose to relate some of the information gathered during my visits to the Continental schools.

SWITZERLAND.—*Zurich Polytechnische Schule.*—The Polytechnische Schule, Zurich, is one of the oldest, as well as one of the most celebrated, of the great Continental technical schools. It is a Federal institution, administered by a Council appointed by the Swiss Government, from which it receives a subsidy of about £40,000 per annum. Applicants for admission must be over eighteen years of age, and are required to pass an entrance examination or to produce the leaving certificate of a Swiss gymnasium, the standard in either case being about that needed for our B.A. degree.

A Swiss boy destined for the Polytechnic enters a primary school at about six years of age. Here he spends four years, then goes for two years to a secondary school, and then to a gymnasium for seven—he is now nineteen years of age and has spent thirteen years at school. Then follows the Polytechnic course of four years, the student receiving his diploma at twenty-three.

The Polytechnic comprises the following separate departments: (1) Architecture, (2) general engineering, (3) mechanical engineering and technology, including electro-technics, (4) chemical technology, (5) forestry, (6) agriculture, (7) land engineering, (8) mathematics and physics, (9) natural science. In 1903 there were 1,263 regular students and 657 *zuhörers*, or a total of 1,920 names on the books. The *zuhörers* (hearers) are outside students not taking any regular course, the admission of whom is controlled by the professors whose classes they wish to attend. The teaching-staff consists of 111 professors and 62 assistants, or a total of 173 without minor assistants and attendants. This gives 7·3 students per teacher.

Here, as at all the Continental universities and technical high schools, the most marked features are, specialisation on the part of the teachers, and repetition on that of the students. The large number of professors and instructors render these features possible. For instance, at Zurich there are no less than seven full professors of chemistry, with many assistants, the subjects being divided into (1) general, (2) analytical, (3) inorganic technical, (4) organic technical, (5) pharmaceutical, (6) electrical, and (7) agricultural.

The Chemical Laboratories are so extensive that a comparatively hasty inspection occupied some four hours. Many of the laboratories appeared to be nearly 300 ft. by 100 ft. Their equipment is complete. The Physical Laboratories, which are under the direction of the famous Professor Weber, are on the same liberal scale; whilst in the Steam and Hydraulic Laboratory, on which some £65,000 has been expended, there are engines, turbines, dynamos, and pumps aggregating over 2,000-horse power. Instruction in the strength of materials and testing is given in the "Profungs Anhalt" or Government Testing-house, where the novel and ingenious method is adopted of evaluating the clays and earths of the country by manufacturing from them model bricks which are burnt and subsequently tested in the laboratory. In this way a brick-and-tile industry is being built up on a firm basis.

Incidentally, it may be mentioned that in Switzerland there exists a system by which an exceptionally promising boy, whose education his parents may be unable to pay for, becomes a ward of the State, by whom he is educated and trained, and, if he desires it, employed.

The feature of the system is selection, as opposed to competitive examination.

GERMANY.—Some six years have now elapsed since the great technical high schools of Germany were given full university status, carrying with it the right to grant degrees. As far as a stranger can judge there is little or no friction between them and the older institutions with which they now appear to rank on absolutely equal terms. Professors are chosen for new posts indifferently from either class of establishment, the status of a chair in a technical high school being the same as that of a similar position in the university.

The technical high schools are State-supported institutions to which entrance as a student can only be obtained by the production of a Maturity Certificate from a German gymnasium or real gymnasium. These certificates are granted after satisfactory attendance for nine years and the passing of a leaving-examination, about equivalent to our B.A. examination in the case of the gymnasium, or B.Sc. examination in that of the real gymnasium pupil. On his entrance having been approved, the student is, for engineering and kindred subjects, advised to spend one year in the workshops, and then embarks on a four-years course, which he completes, and receives his diploma when between twenty-three and twenty-four years of age.

The examinations are chiefly oral, and are invariably conducted by the professors under whom the student has studied. He is usually required to justify the conferring of his degree by writing a thesis, which is printed and circulated through the universities and technical schools of the country.

While at college the average technical student works hard. There are two terms, giving thirty-eight working-weeks in the year, during which he attends lectures and laboratories for no less than forty hours per week. There are naturally a small proportion of idlers: these are much devoted to beer-drinking and duelling, and I am informed that some of their number develop into excellent waiters.

Specialisation by the instructors is most marked, there being on the average about one instructor to every ten students attending these schools.

As far as the training of engineers is concerned, the weak point of the German system appears to be that up to the time of leaving college, if the optional twelve months' work before entrance be excepted, the student has had no real workshop-training, and, although he has had a considerable amount of practice in the laboratories, workshop methods and the character and ideas of the men he may be called upon to control are entirely foreign to him. Many German professors with whom I have discussed this point are in agreement with me as to the superiority of a system in which practice and theory alternate; such a system has been in use here for the last ten years, and is now being warmly advocated in England under the name of the "sandwich system."

The Königliche Technische Hoch Schule, Charlottenburg, Berlin, is a State institution under the immediate direction of the Cultur Minister. It is the largest technical high school in Germany. There are the following departments: (1) Architecture, in which are 495 students; (2) civil engineering with 617; (3) mechanical engineering, with which is included electrical engineering, 1,432; (4) naval architecture, including marine engineering, or, as it is called in Germany, ship and ship-machinery engineering, 365; (5) chemistry and metallurgy and mining, 323; (6) general science and mathematics, 8; total students, 3,260; hospitanten, 897: total, 4,157 students. In addition there are some four hundred officers in the navy and adult persons from various Government Departments taking special courses. A large proportion of the students trained here, especially in engineering and naval architecture, eventually enter the Government service, the Government making extensive use of the school for the training of its departmental officers, a system which might be followed with advantage in this colony.

The small attendance at mathematics and general science is characteristic of all these schools, and is due to: (1) the high standard required at entrance; (2) the academic freedom in choosing his course of study, which is jealously guarded by the German student; (3) a natural reaction from the undue importance, to the average engineer, which was at one time attached to a study of the higher portions of these subjects.

The most striking feature of the engineering course is the amount of time devoted to mechanical drawing and designing, and the manner in which it is taught. Professor Riedler carries on a large consulting practice in the building, and employs some thirty engineers and draughtsmen, under whom the students work more or less as assistants, and from whom they also receive their instruction.

Prominent in the Charlottenburg laboratories are the large experimental tanks in connection with the Department of Naval Architecture, where much of the experimental work of the navy is carried out; the steam-, gas-, and oil-engine laboratory, where the engines aggregate some 1,000-horse power, and to which a professor and several assistants devote their whole time; and a very extensive museum of kinematic and machine models.

The individual laboratories, with the exception of that of naval architecture, are, however, surpassed in size and equipment by some of those of the newer colleges—for instance, what is probably the finest physical laboratory in Europe was at the time of my visit being completed at Leipzig. The building, which approaches in size the Government Buildings here, is built of red brick in the form of a hollow square, and the rooms and laboratories, of which there are nearly two hundred, are on the outer sides and open into corridors surrounding the well, which is covered by glass and used as a machine-room. To every laboratory there is a set of high- and low-tension C.C. and A.C. leads, hot- and cold-water pipes, high-pressure water-service, high- and low-pressure steam-pipes, compressed-air pipes and gaspipes. All these are coloured differently, and strung on the roof of the corridors. There are, however, only two lecture-theatres in the whole building, the displacement of lectures by individual instruction in the laboratory being characteristic of the modern German system.

There is also a large electro-chemical laboratory at Leipzig.

Dresden aspires to be the finest engineering college in Germany. With this object the Dresden Technical High School is being rebuilt on the summit of one of the hills overlooking the town. Already some £200,000 has been spent in buildings and partial equipment, and it is estimated that another £100,000 will be required for completion. This will bring the capital expenditure up to nearly £200 per student on the estimated attendance.

Six separate buildings have been erected. These are—(1) The General Building, in which are the offices (the general science and mathematical instruction is given here, and here, too, are the numerous drawing-offices in which all the drawing is taught); (2) the Physical Building; (3) the Chemical Building; (4) the Mechanical Engineering Building; (5) the Electro-technics Building; (6) the Central Station for heat, light, and power, in which 300-horse power is installed.

The Steam Laboratory contains experimental mill, marine, and superheated steam-engines, two steam-turbines, and several dynamos and pumping-engines.

In the Gas-engine Laboratory there are gas and oil engines, marine and car petrol-motors, with a full equipment of testing-appliances; whilst in the Hydraulic Laboratory there are sets of air and water pumps, Riedler pumps, centrifugal pumps, Thompson's turbines, Pelton wheels, and two large low-fall turbines of 80-horse power each, the supply to which is maintained by electrically driven centrifugal pumps of like capacity. There are also cold-air and ammonia freezing-plants; in all, nearly 3,000-horse power of machinery. [Remarks as to laboratories illustrated by reference to diagrams.]

The Electro-technics Building is slightly smaller than, but arranged on similar lines to, the Physical Laboratory at Leipzig. The Physical and Chemical Buildings are of the same character.

At *Munich* the Technical High School is divided into the following sections: (1) Architecture, (2) engineering, (3) mechanical technology, (4) technical chemistry, (5) general science, (6) mathematics, (7) agriculture.

The laboratories are well equipped, but generally on a smaller scale than those which have been previously described. The students number about nineteen hundred.

The Technical High School, Karlsruhe.—The departments here and number of students attending each are as follows: (1) Mathematics and general science, 12; (2) architecture, 248; (3) engineering, 256; (4) mechanical technology, 456; (5) electro-technics, 293; (6) chemical technology, 223; (7) forestry, 32: total students, 1,520; hospitanten, 151: total, 1,671 students. There are 129 professors and lecturers.

The department for electro-technics is celebrated from having at its head Dr. Arnold, formerly chief of the Great Orlikon Electrical Company, and the example set here has been followed at Dresden, where, by the payment of another large salary, Dr. Geörges, the chief designer of Messrs. Siemens and Halske, was secured. In fact, the necessity for practical instruction by professional men, as opposed to the teaching of the theory by the pure scientist, in the latter portion of an engineer's training is now fully recognised in Germany, where the pernicious system of appointing the great man's bottle-washer to the minor chair is, at all events for practical subjects, at an end.

In the Engineering Laboratory at Karlsruhe there is a most interesting experimental tank of large dimensions, in which the flow of rivers and the effect of dams and other obstructions can be studied. Any desired contour is built up of tiny sandbags in sand or cement and by means of numerous and ingenious appliances the pressure and flow of water noted. With the assistance of an electric motor the tank can be tilted to any angle. [Remarks *re* laboratory illustrated by reference to diagram.]

The Darmstadt Technical High School boasts of the largest and most completely equipped electro-technical laboratories in the Old World. In connection with these laboratories there is a most interesting museum of modern appliances, from which yearly all superseded devices are removed. The steam- and gas-engine laboratories are extensive, and the hydraulic laboratories approach those of Dresden in size and equipment. There is a sub-department and professor of cycle-building, which is now being developed to include automoble-construction.

The chief departments and students attending are: (1) Architecture, 172; (2) engineering, 229; (3) machine-construction, 518; (4) electro-technics, 391; (5) *(a)* chemistry 80, *(b)* electro-chemistry 48, *(c)* pharmaceutical 23—151; (6) general science and mathematics, 31: total, 1,496; hospitanten, 308: total, 1,804 students. There are 116 professors and lecturers.

The marked success of the isolated German technical high schools, as compared with that of professional schools attached to universities, is attributed to the fact that by insisting on a high entrance qualification the technical high schools are enabled to become completely self-contained, and thus to teach the collateral subjects of mathematics, physics, and chemistry, as a means to an end, laying special stress upon their application to the professional work of the student. On the other hand, at the universities these subjects are too often taught for university purposes only, and the technical student is required to absorb a large amount of, for him, useless matter, whilst his labour is in no way lightened by practical application to the problems of his profession. Further, he is under divided control, in which there is sometimes the reverse of unity of purpose, and from which more often than not he receives contradictory advice. Discouraged and disheartened, he turns to amusement and attempts to combine the relaxations which are possible for a man taking a pass degree with the much heavier work of a professional course, and then, though he may finally scrape through his examinations, he is in no sense of the term a qualified professional man, and infinitely inferior as a leader of industry to his brother of the technical high school.

From the technical laboratories have sprung the two great research institutions of Germany, the Reichsanstalt and the Mechanische-Technische Versuchsanstalt. The former, which is under the direction of Dr. Kolrüshe, undertakes all descriptions of physical and chemical research. The latter, of which Dr. Martens is the head, carries on the testing of metals, building-materials, paper, and oil. There is also a Department of Metallographie under Professor Heyn. At both establishments the buildings are extensive, the plant elaborate, and a large number of skilled professors are engaged solely upon work which has for its object the advancement of German industry.

As an example of one of these industries the speaker proposes to give a short description and show views of the firm of Fried. Krüpp at Essen Ruhr, which he was granted exceptional facilities for inspecting. From these works steel in almost every form is sent to all parts of the world. The output includes open-hearth, Bessemer, crucible, chrome, nickel, and tool steel; rails, tires, axles, propellers, shafts, and engine-details; armour, guns (of which more than forty thousand have been made), gun-carriages, and munitions of war. The size of these works can be better realised when it is mentioned that they include sixty departments in which twenty-five thousand people are employed, are equipped with 45,000-horse power, and consume 1,700,000 tons of coal per annum. The firebrick and crucible factories turn out no less than 2,000 crucibles per day, which are all used in the steel-works. The gasworks are the third largest in the German Empire, and supply 19,000,000 cubic meters of lighting-gas per annum. The firm owns an excellent hotel, a hospital, convalescent-homes, over a hundred shops and stores, and six thousand family dwellings, housing twenty-seven thousand people. Quarters are provided in the Alterhof Colony for aged, disabled, and pensioned workpeople. There is at Hügel an extremely good club, of which higher officials are members.

A number of views, illustrative of his address, were shown on a screen and explained by Professor Scott. In connection with those of the Municipal School of Technology, Manchester, he remarked as follows:—

The buildings and equipment of this school have been planned on German lines, and it is in these particulars by far the finest and most complete in England, and compares favourably with its Continental prototypes. But, though the teaching-staff has been carefully selected and includes many men of worldwide reputation, there exists the want of definite aim to which I have already alluded. This the syllabus itself indicates, the subjects taught including mechanical engineering, physics and electrical engineering, municipal and sanitary engineering, geology, metallurgy, upholstering, horology, breadmaking, house-painting, iron-founding, photography, weaving, dyeing and spinning, brewing, dressmaking, &c., microscopic investigation, &c.—in fact, almost every conceivable subject taught to students of widely differing education and capability. Division into a technical high school, attached to the Victoria University, and a trade school proper is now under consideration.

In conclusion, Professor Scott showed some views of the School of Engineering at Canterbury College, regarding which he made the following remarks:—

These views are not introduced with the object of comparing our equipment with that of the magnificent teaching-establishments of the Old World, but to show that something is being done to assist our young men to prepare for competition with their highly-trained Continental rivals. How much more remains to be accomplished to enable them to compete on even terms, and in what direction, it has been the aim of this address to indicate.

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