

either forming a regular series or constituting an irregular sea. In these approximations allowance can be made for the effect of water-resistance to the rolling motion—a most important factor in the problem which could not be dealt with until experimental research had been made, and results had been subjected to mathematical analysis. In addition, Froude laid down certain practical rules for the guidance of naval architects, and the application of these rules has been shown by long experience to favour the steadiness—that is to say, the comparative freedom from rolling—of ships designed in accordance with these rules. In short, a problem which had proved too difficult when attacked by Daniel Bernoulli in purely mathematical fashion was practically solved a century later by Froude, who employed a combination of mathematical treatment and experimental research.

Another example of the contrast between earlier and present methods is to be found in the treatment of the resistance offered by water to the onward motion of ships. From an early date mathematicians have been attracted to this subject, and many attempts were made to frame mathematical theories. When steam-propulsion for ships was introduced, the matter became of great practical importance, because it was necessary to make estimates for the engine-power required to drive a ship at the desired speed. In making such estimates it was necessary to approximate to the value of the water-resistance at that speed, although the required engine-power was also influenced by the efficiency of the propelling apparatus and propellers. In addition, it was obvious that the water-resistance to the motion of a ship when she was driven by her propellers at a given speed would be in excess of the resistance experienced if she were towed at the same speed, and there was no exact knowledge in regard to that increment of resistance. The earlier mathematical theories of resistance proved to be of little or no service, and they were based on erroneous and incomplete assumptions. Rankine devised a "stream-line" theory which was superior to its predecessors, but it also for a time had no effect on the practice of naval architects. William Froude, adopting this stream-line theory, dealt separately with frictional resistance, and devised a "law of comparison" at corresponding speeds, by which from the "residual resistance" of models—exclusive of friction—it became possible to estimate the corresponding residual resistance for ships of similar forms. At first he stood alone in advocating these views, but subsequent experience during forty years has demonstrated their soundness.

Experimental tanks for testing models of ships, such as Froude introduced, are now established in all maritime countries, and the results obtained therein are of enormous value to the designing of steamships. In regard to the selection of the forms of ships, naval architects are now able to proceed with practical certainty; but in connection with the design of screw propellers, even after model experiments have been made with alternative forms of screws, there is still great uncertainty, and dependence upon the results obtained on "progressive" speed trials of ships is still of the greatest service. As yet the "law of comparison" between model screws and full-sized screws has not been determined accurately. The condition of the water in which screws act, as influenced by the advance of a ship and her frictional wake, the phenomena attending the passage of the water through a screw, and the impression thereon of sternward motion from which results the thrust of the propeller, the effect upon that thrust of variations in the forms and areas of the blades of screw propellers, and the causes of "cavitation," all form subjects demanding further investigation. In these cases the only hope of finding

solutions lies in the association of experimental research with mathematical analysis. There have been very many mathematical theories of the action of screw propellers, but none of these has provided the means for dealing practically with the problems of propeller design, and there is no hope that any purely mathematical investigation ever will do so, because the conditions which should be included in the fundamental equations are complex and to a great extent undetermined.

In connection with other branches of engineering, model-experiments have also proved effective. Examples are to be found in connection with the estimates for wind-pressure on complicated engineering structures, such as girder or cantilever bridges. Experimental methods are also being applied with great advantage to the study of aeronautics and the problems of flight.

The association of the mathematical analysis of past experience with designs for new engineering works of all kinds is both necessary and fruitful of benefits. A striking example of this procedure is to be found in connection with the structural arrangements of ships of unprecedented size, which have to be propelled at high speeds through the roughest seas, to carry heavy loads, to be exposed to great and rapid changes in the distribution of weight and buoyancy, and to be subjected simultaneously to rolling, pitching, and heavy motion, as well as to blows of the sea. In such a case purely mathematical investigation would be useless; the scientific interpretation of past experience and the comparison of results of calculations based on reasonable hypotheses for ships which have seen service with similar results of calculations for ships of new design are the only means which can furnish guidance.

In the past the association of mathematicians and engineers has done much towards securing remarkable advances in engineering practice; and in future it may be anticipated that still greater results will be attained now that the true place of mathematicians in that practice is better understood and utilised.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

A GREAT cause of anxiety to those who are responsible for evening continuation schools and classes lies in the spasmodic attendances and lack of continuity of the casual student. The prospectus of the Municipal Technical Institute, Belfast, shows that the authorities in that city deal with this source of trouble courageously. Students must submit to an entrance examination, and must follow a course of study, and "any student who does not wish to conform to the regulation as to attending a definite course of study or passing the entrance examination can obtain exemption on making application at the office and paying *treble* the fee for the class it is desired to join." Side by side with these restrictions there is every opportunity and incentive to the serious student to equip himself thoroughly for his business.

THE London County Council announces that the evening classes held in Polytechnics, technical institutes, schools of art, commercial centres, and evening schools will shortly be reopened. The programme which the Council has prepared includes classes to meet all kinds of needs. The enrolment of students began on Monday, September 16, and a leaflet giving full particulars as to where the classes are held, and as to fees (which it may be stated are very low), can

be obtained at any of the Council's schools and of the Education Officer, Education Offices, Victoria Embankment. It is hoped that the efforts of the Council to improve the education of the young people of London by means of these valuable classes will result in a large influx of new and earnest students in the session now at hand.

THE 90th session of the Birkbeck College will commence on Wednesday, September 25. The opening address will be given in the theatre at 7.30 p.m., by Sir Sidney Lee. The class-rooms, &c., will afterwards be open for inspection, and there will be an exhibition in the Art School. The college is conducted in relation with the University of London; classes are held both in the day and evening; twenty-nine members of the staff are recognised teachers of the University. There is a very complete curriculum for chemistry, physics, mathematics, botany, zoology, and geology. The laboratories are well equipped with modern apparatus and appliances, and research work is encouraged in all the science departments. According to the calendar more than 118 students passed some examination of the University during the last session: forty-nine took degrees in arts or science, twenty-two with honours, and several students gained distinction at other universities.

THE new session of the Battersea Polytechnic opened on Tuesday, September 17, and the calendar gives full details of all the numerous courses and classes held at the Polytechnic. In the Day Technical College full-time courses are arranged in mechanical, civil, electrical and motor engineering, architecture and building, chemical engineering, and art, the courses covering a period of three years, at the end of which time students passing the necessary examinations are awarded the Polytechnic diploma. There are also full university and diploma courses in mathematics, physics, chemistry, botany, &c. Concurrently with the diploma courses, students can prepare for and take the degree courses in science and engineering of the University of London. In the electrical engineering department, a new course in electric lighting and illumination will be held during the second term of the session. The greatest development to be recorded this year is in the department of natural science, *i.e.* including the subjects of hygiene, physiology, geology, and bacteriology. The recent donation of 6000*l.* made by the Worshipful Company of Drapers has enabled the governing body to erect a four-storey building for the housing of the above sections of work, and thus airy and well-lighted laboratories and lecture-rooms of the latest design, and fitted with the most modern equipment, are now available for this most important work.

AN influentially signed appeal has reached us for support to a scheme for providing a systematic course of combined military and industrial training for lads from the age of fourteen years upwards. The object of the British Boys' Training Corps, on behalf of which the appeal is made, is the moral, physical, and industrial advancement of the cadets enrolled in it, to train them in the duties of citizenship, and to fit them for a life of industry. Military organisation and exercise will be used as a means for developing their moral and physique, and promoting among them habits of discipline, application, adaptability, and resourcefulness, which are indispensable to proficiency in the workshop or the factory. The corps will, in effect, be a military and industrial boarding-school, and is designed to train and instruct a boy for a period of three or four years continuously from the time he leaves the elementary school. Alike upon

social, economic, and industrial grounds the scheme is commended to the public. The annual loss to the nation of promising material presents a grave problem. Far too many boys on leaving school are engaged in "blind-alley" occupations; when they have outgrown these, they find themselves adrift without either the skill or the knowledge to qualify them for permanent employment; they swell the ranks of casual labour, and the prison or the workhouse is the ultimate destiny of an increasing number of them. To mitigate these evils in some measure at least is the aim of the corps. It is estimated that the cost of establishing and maintaining the corps at first will be 15,000*l.* No appeal for funds has hitherto been made, but two members of the council have generously promised to guarantee 1000*l.* and 500*l.* respectively towards the expenses on condition that the total amount guaranteed or subscribed is not less than 15,000*l.*, and various unsolicited donations, including an anonymous one of 50*l.*, have already been placed to the credit of the corps at the Bank of England. Guarantees, donations, or subscriptions may be sent to the account of the corps at the Bank of England (Western Branch), Burlington Gardens, W.; to Colonel Pollock, Wingfield, Godalming; or to the hon. secretary, Mr. J. C. Medd, 37 Russell Square, W.C., from whom particulars of the scheme can be obtained.

SOCIETIES AND ACADEMIES.

PARIS.

Academy of Sciences, September 2.—M. P. Appell in the chair.—A. Lacroix: The origin of the transparent quartz of Madagascar. The hyaline quartz of Madagascar is of complex origin, but there are only two classes of deposits furnishing the mineral in large quantities and of sufficient transparency for industrial purposes. One of these is in lodes of the Ampangabé type, in which the quartz is without crystalline form; the other is of hydrothermal origin, and here the quartz forms well-defined crystals.—A. Ricco: Filaments, *alignements*, and solar prominences. The author confirms the view that there is a relation between the prominences and the filaments and *alignements*.—Jean Danysz and William Duane: The electrical charges carried by the α and β rays. From the experiments described the electrical charge carried by the α rays of one Curie of emanation in equilibrium with radium A, B, C is deduced as 90.8 electrostatic units per second, or nearly three times the charge found by Rutherford for radium C alone in equilibrium with one Curie of emanation. From this constant are deduced the volume of one Curie of emanation (0.595 mm.³ at 15° C.), and the volume of helium given off by one gram of radium in equilibrium with its emanation and radium A, B, and C (157 mm.³), both in good agreement with the experimental values.—Victor Henri and René Wurmser: Study of the law of photochemical absorption for reactions produced by the ultra-violet rays. There is a striking parallelism between the absorption curve of acetone in the ultra-violet and the chemical activity of the different rays. This reaction affords an example where the extreme ultra-violet rays are less active chemically than ultra-violet rays of greater wavelength.—Claude Verne: *Solanum maglia* and *tuberosum*. and the results of experiments on cultural bud mutations undertaken on these wild species of potato.—H. Busquet: The comparative cardiac action of the physiological extract of digitalis and other digitalis preparations.—Romuald Minkiewicz: *Ciliata chromatophora*, a new order of Infusoria with un-