formulæ are correct, the inverse calculation provides a spectroscopic method of determining the mass of the electron. The available observations give the mass of the hydrogen atom in terms of that of the electron as 1836±12, in remarkable agreement with the generally accepted value.

Until other evidence is forthcoming, it may be considered that the line spectrum of hydrogen consists only of the Balmer series, with parallel series in the infra-red and extreme ultra-violet. The proto-helium spectrum is of the same simple character, and this simplicity gives the two spectra a special value in theoretical investigations. Bohr's theory implies that arc series in general are produced when only one electron is removed from the atom by the exciting source, and spark series when two electrons are removed.

The change in the character of the series in passing from arc to enhanced lines suggests the possibility of series requiring still greater multiples of the ordinary series constant, but no such series have yet been identified.

PRACTICAL EDUCATION IN SECONDARY SCHOOLS, TRADE SCHOOLS, AND CENTRAL SCHOOLS.[1]

ONE of the most striking features of English education at the present time is the attempt which is being made to give a more practical or vocational bias to the training of boys and girls between the ages of twelve and sixteen years—that is, after the completion of the ordinary primary-school curriculum. So far as day work is concerned, this tendency is operating along two main lines, (*a*) the modification of the traditional secondary-school course by the introduction in some schools of elementary engineering, agriculture, shorthand, typewriting, or of subjects grouped under the general name of "educational handwork" (*e.g.* woodwork, metal-work, domestic subjects for girls); (*b*) the development of schools (central schools, junior technical schools, trade schools) with a pronounced vocational object.

A. *Secondary Schools.*—In the year 1911–12, of the total number (39,726) of new admissions to the secondary schools aided by the Board of Education, no less than 67·7 per cent. came direct from the elementary school. Clearly the great majority of these cannot enter one or other of the learned professions, but must devote themselves on leaving school to some branch of commercial or industrial life. A strong public demand has arisen for a modification of the curricula of these schools so that the education given may be of more direct value to the pupils after leaving school. Employers are demanding better trained assistance; the parents feel that the additional sacrifices they must make in order to keep their boys and girls at the schools after fifteen years of age are not sufficiently justified by the benefits to be derived by their children from an education which is mainly of a literary or classical type. As a result, some secondary schools have specialised to a certain extent, more particularly of course in the higher forms, in engineering subjects, others in science (chemistry, physics, botany, and biology) as applied to agriculture, others in commercial and secretarial work, depending upon the needs and circumstances of the locality. Apparently the results of this specialisation, where it has been attempted, have been satisfactory. The general educational work of the school has gained in interest and vitality by the increased contact with concrete, everyday affairs. Possibly it may help also in checking the exodus of the pupils from the secondary schools at about the age of fifteen, *i.e.* half-way through their full course.

The Consultative Committee of the Board of Education issued a short time ago a comprehensive and suggestive report upon the development of "educational handwork" of various kinds (woodwork, metal-work, gardening, modelling, and domestic subjects for girls) in secondary schools. The report states (p. 5) that the evidence of the witnesses "leaves no room for doubt as to the necessity and the practicability of giving such work a more definite place in secondary education than it has hitherto occupied, and of associating it so far as possible with the rest of the work of the school." While it is not the function of the secondary school to impart technical instruction, it should provide those of its pupils whose future callings may involve manual work or the utilisation and control of such work with a foundation on which technical instruction may subsequently be built. "Systematic work with the hands is a necessary constituent of a liberal education." To train deftness of hand, although important, is not the sole or even the chief aim of handwork teaching. The principal object is to influence the mind and character of the pupils by developing their common sense, readiness, and adaptability. In addition it brings the work of the school into close relation with the needs of daily life outside the class-room, thus giving school work that reality which is so important for arousing the child's interest. Manual training has a valuable steadying influence upon the over-quick and excitable child, and a stimulating effect upon the child who is naturally slow at abstract mental processes.

The recognition of handwork as a compulsory school subject has been objected to on the ground that it involves the addition of one more item to an already overburdened time-table. Experience shows that a reasonable amount of time devoted to handwork does not lead to any lowering of attainment in other branches of school work, but rather the reverse.

The Committee lays down the following general principles for the teaching of all branches of educational handwork. The encouragement of independence and initiative is of fundamental importance, hence each pupil should be allowed to work at his own pace and be encouraged to select his own work. Classes should be sufficiently small to permit of individual instruction. Constructive practice and theory should go hand in hand. The syllabus should be logical, coherent, interesting, and of a direct culture value. A number of syllabuses which are in actual operation in schools are given in the report. These will be of great value to teachers.

Handwork should be recognised in any general examination scheme for secondary schools. External examinations in this subject are particularly undesirable; the assessment of the progress made by the pupil should be based upon the work done during the course.

The Committee points out that at the present time the educational training, status, and remuneration of handwork teachers are unsatisfactory. These teachers should be on an equality in these matters with their colleagues. This type of teaching should not be handed over to artisans, but to men with a good general education and a special knowledge of educational handwork. The universities should provide increased facilities for this branch of education, and adequate recognition of those who complete successfully the prescribed courses of study.

B. *Central Schools, Junior Technical Schools, Trade Schools.*—In this group of schools the work as a

[1] (1) Report of the Consultative Committee of the Board of Education on Practical Work in Secondary Schools [Cd. 6849]. (Wyman and Sons, 1913. Price 1*s.* 9*d.* (2) Report of the Board of Education for 1911–12 [Cd. 6707]. (Wyman and Sons, 1913.) Price 8½*d.* (3) Regulations for Junior Technical Schools in England and Wales [Cd. 6919]. (Wyman and Sons, 1913.) Price 1½*d.*

whole has a more pronounced practical or vocational bias than in the secondary schools, this being most marked in the trade schools and least in the central schools. The students in these schools are in nearly every case drawn from the elementary schools. The usual age of admission is twelve or thirteen years, the courses lasting three to four years. The fees are nominal, ranging from 10s. to about 2l. 10s. per annum. There is usually a generous supply of scholarships with maintenance grants awarded by the local education authority.

(1) *Central Schools.*—The last Board of Education report (*i.e.* for 1911–12) states that central schools have been established only in London and Manchester as yet. In London there are thirty-one such schools containing forty-two departments, fifteen for boys, thirteen for girls, and fourteen "mixed"; nineteen of these departments have a commercial bias, sixteen industrial, and seven a "dual" bias. Manchester has six such schools, including three boys' departments, two girls' departments, and three mixed departments.

These central schools are intended to attract at about the age of twelve or thirteen the best boys or girls from the local elementary schools, who have not previously been drafted off by means of competitive scholarships into the secondary schools. The object of the schools is to continue the general education of the pupils and at the same time to prepare the children to go directly at about the age of fifteen or sixteen into business houses or workshops at the completion of the course. The training is to be such, however, that it will not prevent the pupil proceeding by scholarships or otherwise to a place of higher education.

An examination of the curricula of these schools reveals comparatively little difference between them and those secondary schools which have definitely attempted to introduce vocational work into their programme. A typical central school (with a commercial bias) provides throughout the whole course, in addition to the ordinary subjects, such as mathematics, geography, and history, about four hours a week for a modern language, four hours a week to English, science two hours, manual training two hours, and drawing two hours. In the third and fourth years a few hours a week are devoted to shorthand, business correspondence, office routine, and typewriting. In departments with an industrial bias, about ten to twelve hours a week are given to practical work (laboratory work, drawing, woodwork, and metalwork). No attempt is made to specialise for any one particular industry. The practical work for girls consists of elementary science and housecraft. This type of school as a whole, though doing excellent work, suffers somewhat in the public estimation through it being regarded as inferior in prestige to the ordinary secondary school. The training given in the central schools is probably better fitted to the after circumstances of the majority of boys and girls from the elementary schools than is that afforded by the usual type of secondary schools.

(2) *Junior Technical Schools and Trade Schools.*—This class of schools suffers from a bewildering variety of names—junior technical schools, trades preparatory schools, pre-apprenticeship schools, and trades schools. Generally speaking, the junior technical schools provide a wider training in general education and in theoretical work than the trades schools. Again, junior technical schools are understood not to specialise for one particular trade, but to provide a training enabling a boy to enter any branch of a group of industries, such as engineering or the building trades. The trades schools specialise more severely than this in many cases. Actually, the names of the schools are often misleading, so-called "trades" schools being really "junior technical" schools. At the present time the general tendency is in favour of the "junior technical school," with its wider educational outlook and less severe specialisation, rather than the "trades" school proper.

There are about sixteen junior technical or trades schools in London, with about 800 boys and 3000 girls in attendance. In other portions of England and Wales there are about twenty such schools, with, say 1200 pupils, and in Ireland twelve schools with 500 pupils. Scotland relies upon a system of "supplementary classes," which in effect is very similar to the "central schools" described earlier.

The provincial schools are usually designed to provide only for the engineering, building, and metal trades. Manchester has recently established a Day Trade School of Dressmaking. London trade schools cover a wide field of more or less specialised instruction, *e.g.* furniture and woodworking trades, book production, silversmith's work, tailoring, bakery and confectionery, cookery (for *chefs*), and many women's trades. The net annual cost of the trade schools maintained by the London County Council is approximately 15l. to 21l. a student. There is no definite provision, except at Cardiff, for instruction in commercial subjects along junior technical-school lines.

The curricula of these schools vary considerably. Broadly speaking, each school allows about three to four hours a week for English, three to four hours a week for mathematics or arithmetic, and of the remaining time, about one-third is devoted to theoretical instruction in the theory or sciences, if any, allied to the special trade or industry, and about two-thirds to the practice of the trade or practical work (including drawing office, workshops, laboratory work, or drawing) connected with the industry. Considerable attention is given to continuing the general education of the pupils, with the result that but for the omission of a modern language, the boy of sixteen in the better type of junior technical school is educationally on a level with the average boy of the same age in the secondary school. The physical welfare of the children is helped through the agency of organised games and gymnastics. The pupils are encouraged to organise clubs and societies in order to foster the social life and corporate spirit of the schools.

On the whole this type of school has been very successful, especially perhaps the trade schools for girls in London. Close contact with the trades and industries is secured in many of the schools by the formation of "advisory committees," consisting of representatives of employers and of labour. The pupils are generally keen upon their work, and the tone of the schools is good. There is comparatively little difficulty in most cases in securing positions in industrial life for the boys or girls at the completion of their course. The work done in these schools generally enables the boy or girl to shorten the period of apprenticeship very considerably and to obtain higher wages than they would otherwise have secured.

The success of the relatively few junior technical schools or trades schools which have been established so far points to the probability of a rapid increase in the number of these schools in the immediate future. Broadly speaking, about half a million boys and girls leave the elementary school each year, less than one-tenth of these passing forward to the secondary school, and only about 2000 to the junior technical or trades schools. Of the remainder, a considerable proportion would probably amply repay further systematic full-time education, not of the customary literary type, but of a more practical character, such as is given in the junior technical or trade schools. One point, however, must be watched. The Board of Education, in the recent regulations for junior technical schools, states that these schools are not intended to furnish a preparation for higher "full-time" technical work, this being one of the functions of the secondary school. This would make the junior technical schools a "dead end" so far as further day technical work is concerned. In science and mathematics, the fundamental subjects in technical work, the boy in the junior technical school is ahead of the secondary-school boy. The junior technical school should be another avenue, alternative to the secondary school, by means of which the bright boy could pass from the elementary school to the technical college. This is especially important in the case of the boy who develops somewhat late or whose mental activities only become aroused by contact with things rather than with books.

J. WILSON.

THE INSTITUTION OF NAVAL ARCHITECTS.

THE spring meeting of the Institution of Naval Architects opened on April 1 at the rooms of the Royal Society of Arts. The institution's gold medal was awarded to Mr. G. S. Baker, for his paper on methodical experiments on mercantile ship forms. Premiums were awarded to Messrs. A. Cannon and L. Woollard for papers dealing respectively with the effect of loose water on the rolling of a ship, and the effect of water chambers on the rolling of ships. In all fourteen papers were read and discussed during the three days over which the meeting extended.

In a paper dealing with some questions relating to battleship design, Mr. T. G. Owens states that the present tendency in warship construction and design, as exemplified in the later ships of all the principal maritime powers, is towards very large displacements, with the arrangement of all the guns of the primary armament on the centre line, and with the guns of the secondary armament placed in an armoured citadel on, or immediately below, the deck carrying the primary guns. In respect to the above-water armoured protection, there is the usual thick armoured belt, extending, say from 4 to 6 ft. below the water-line, to the height of the main deck, and carried along the length of the vessel for such distance as to protect the machinery and boiler compartments and the magazines. The ends of the ship and the citadel have armour of reduced thickness. In all modern battleships there are horizontal protective decks. Protection against attack from bombs, etc., dropped from aircraft is not yet in the region of practical politics. When the time arrives to arrange measures to meet such attack, they will probably take form in the method advocated by Sir Trevor Dawson, *i.e.* to increase the thickness, and give a greater curvature, or whale-back formation, to the armoured deck.

Mr. W. J. Luke contributed a paper on experiments upon wake and thrust deduction, supplementary to another paper which he presented to the institution in 1910. The present paper has particular reference to experiments with contrary-turning screws on a common axis, with tandem screws, and also of experiments with quadruple screws. It appears from the experiments that the first-mentioned type of screw has not a little to recommend it, and were the engineering difficulties connected with its application to marine propulsion overcome, it would be well worthy of consideration. Tandem screws have nothing to recommend them.

Mr. J. T. Milton read a paper on the present position of Diesel engines for marine purposes, and Prof. W. E. Dalby described some results of trials made on a small Diesel engine in which accurate indicator diagrams were obtained by means of a new form of optical indicator.

Mr. G. S. Baker gave an account of a number of model experiments made to determine the effect of shape of area curve on the resistance at any reasonable speed. This paper gives also a brief account of the work of the year at the William Froude tank. A large proportion of time has been spent on test work for various shipbuilding firms. The resistance of at least five large vessels has been reduced more than 10 per cent. by modifications to the form made at the tank, and several others have been improved in a less degree. The importance and value of these results can be seen from the fact that the saving in cost of coal per annum for a single one of the above five ships would be more than sufficient to support the experimental tank for the same period. The investigation of the resistance and tipping moments experienced by aero-hydroplane floats has been continued. Considerable improvement has been effected in the power required for their propulsion, the tipping moments due to the water forces are now known, and a float which is stable in character and of a low water resistance has been evolved. Ship models have been tested with four different kinds of surface, the paraffin wax being (*a*) bare, (*b*) freshly coated with shellac varnish, (*c*) the same, with blacklead rubbed into a coating of shellac when the latter was "tacky," and then allowed to harden, (*d*) coated with red lead paint. The spots from the four surfaces were indistinguishable, and show that, provided the surface is smooth and free from grit, the same result will be obtained.

Mr. H. Gray gave the results of experience with superheated steam, with special reference to economy and cost of upkeep, based on more than three years' working in engines of both triple- and quadruple-expansion types in the mercantile marine engaged in regular trade, voyage after voyage, to Australia *viâ* the Cape of Good Hope. The system adopted was the Schmidt. None of the steamers have been delayed either in port or on the voyage by reason of superheater defects, notwithstanding the fact that the runs are long—that of the *Port Augusta* being forty-five days without a call at any port. Lubrication of the cylinders and valve faces is of the utmost importance with superheated steam, and it is absolutely necessary to have a trustworthy system of filtration for the feed-water, so as to ensure the abstraction of the oil and to safeguard the boilers from the possibility of any traces of oil being introduced. The author states that the economy of triple-expansion engines of 2000 i.h.p. after being altered to use superheated steam, has been increased about 12 per cent., and of quadruple-expansion engines, about 17·8 per cent.

Mr. C. E. Stromeyer contributed a paper on the elasticity and endurance of steam pipes, and a note on the Foster strain meter, and some data obtained therewith were presented by Mr. W. R. Gerald Whiting.

Dr. K. Suyehiro, professor of naval architecture at Tokio Imperial University, described a new torsion-meter which he has devised. This instrument has some interesting features. The angle of twist of the shaft is measured by the relative rotation of two arms, one clamped to the shaft, and the other carried by a long tube clamped to the shaft at the end remote from the other arm. The first-mentioned arm carries a scale having half-millimetres along one edge and a reading scale along the other. The scale faces the shaft, and mounted on the same arm is a plane mirror, situated half-way between the shaft axis and the scale. Hence a virtual image of the scale will be seen every revolution, coinciding with the shaft axis, and therefore at rest. On the other arm is a concave mirror which forms an image of the reading edge of the scale, also on the shaft axis, and side by