SCIENCE

A WEEKLY JOURNAL DEVOTED TO THE ADVANCEMENT OF SCIENCE, PUBLISHING THE OFFICIAL NOTICES AND PROCEEDINGS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

FRIDAY, SEPTEMBER 13, 1901.

CONTENTS:

MSS. intended for publication and books, etc., intended for review should be sent to the responsible editor, Professor J. McKeen Cattell, Garrison-on-Hudson, N. Y.

THE CARNEGIE TECHNICAL SCHOOL.*

IT was the intention of your vice-president to prepare an address on the Evolution of the Mechanics of the Telescope for presentation before Section D of this Association, but a new and important theme has been brought before me by reason of intimate association therewith, and to which a number of the members of this Section have contributed most valuable data. I therefore beg to present to you a few notes upon this subject, namely, the technical school for which Mr. Andrew Carnegie has most generously proposed to furnish the means to build, equip and endow in the city of Pittsburg. When Mr. Carnegie gave to the city its library, its art gallery, its temple of music and its museum, neither the donor nor the citizens had the remotest dream of what they would develop into, nor how far their influence would reach and be felt. I need not tell you what potent factors these institutions have been as educators in the realms of art, science and literature. Suffice it to say, that every department of the great institute has proved itself worthy of its name and is doing marvelous work for the betterment of the people. So marked has been this development during the six years of the existence of the Pittsburg Institute that Mr. Carnegie has given over three million dollars to enlarge its boundaries and increase its influence.

But Mr. Carnegie had promised even greater things for the city of his adoption. He knew as well as any man the need, the great value of a school of technology in

*Address of the vice-president and chairman of Section D, Mechanical Science and Engineering, of the American Association for the Advancement of Science, Denver meeting, August, 1901.

Pennsylvania's great hive of industry; and with but little preliminary discussion of the subject, with full confidence in the commission that had been entrusted with the building, care and development of the Pittsburg Institute, he proposed to furnish the means to build, equip and endow a school of technology on the broadest possible basis, whose doors should be open not only to students from western Pennsylvania, but eventually to students from any part of the world.

President Frew of the Carnegie Commission appointed two committees: (A) A committee to confer with the city officials in reference to a site for the building, etc. (B) A committee on 'Plan and Scope' of the proposed technical school. On this latter committee President Frew appointed the following gentlemen:

President Wm. McConway, of the McConway, Torley Manufacturing Co.; Chas. M. Schwab, president Carnegie Steel Co.; Wm. A. Magee, 'Times Publishing Co.'; Hon. Wm. A. Diehl, Mayor of Pittsburg, and John A. Brashear.

After a series of important meetings in which the best plan of procedure was carefully discussed, Mr. Schwab found it necessary to resign as a member of the committee, as he had been called to the position of president of the United States Steel Co. The resignation of Mr. Schwab was greatly regretted, as he has had large personal experience in technical and manual training schools, having built and endowed a splendid school in Homestead, Pennsylvania, in the very center of the great steel industries. Mr. W. Lucien Scaife was appointed to fill the place made vacant by the resignation of Mr. Schwab. He is a graduate of the Sheffield Scientific School and has studied in the technical schools of France and Germany, and his technical and practical knowledge has proved of great value in the deliberations of the committee.

After a careful discussion of the plan of procedure it was decided to call to our assistance a number of the best men on technical lines in the country, rather than one man, no matter how thoroughly he might be posted in technical school matters, for the one man might have a bias, either of education or environment, which, while it possibly would be in the direction of the very best plan and scope for the new school, might be detrimental to its highest development; and in this important matter it was concluded that in the 'multitude of counsellors' there ought to be wisdom. The committee therefore called to its assistance, Dr. Robert H. Thurston, Professor J. B. Johnson, Dr. Thomas Gray (all members of Section D of the Association) and Dr. Victor Alderson, acting president of the Armour Institute of Chicago. These gentlemen were to come to Pittsburg last spring to study the conditions and environment which would necessarily be important factors in formulating the plan and scope of the new school and, after several pleasant meetings with our own committee, arranged to return to Pittsburg on the 24th of June to make at least a preliminary, if not comprehensive and final report. In the meantime the original committee found much work to do, for communications were coming from eminent technologists, technological societies, domestic art associations, educators in manual training schools and mechanical engineers, all of which contained much good grain, with here and there a hobbyist whose theories were mixed with a good deal of chaff; but on the whole we found a widespread interest in the development of what, let us hope, will eventually become one of the best institutions for technical instruction in this good land of ours. It is for the purpose of leading the members of this Section of the American Association to take an interest in the new school, that this paper is written. It contains no new

thought, no new theories, but calls for your help in a project which we believe will be for the betterment of a large class of students, whose means are necessarily limited, but who will be, let us profoundly hope, mighty factors in the future development of American technological and allied industries.

If we are to keep fast hold of the prestige we have gained in the industrial world by hard work and persistent effort, we must open the storehouse of knowledge to our future mechanicians, engineers, etc., give them an opportunity to partake of the treasures stored therein, and we shall have no fear of the position we are to occupy in the coming years.

Our advisory committee, having studied the problem from many points of view, met with us in Pittsburg on the twenty-fourth of June last, each member having formulated his plans without consultation with other members of the committee, yet it is a matter of interest to know that the expressed views of the advisory board as individual members were so nearly in accord on the general principles formulated for the great school of technology. Of course with such a field to work upon, there were a number of most valuable suggestions made by the individual members of the board, all of which will be of use to our committee in making up its report to the commission.

With your permission, and I am sure with that of the several members of the advisory board, I will give as briefly as possible an outline of the scheme for the new technical school.

First, as to site. The Carnegie Institute is situated in Schenley Park; and it was thought desirable by Mr. Carnegie and members of the commission to secure, if possible, enough ground near the Institute for the technical school. A tract of eleven acres was the only available land in the Park, but this was at once pronounced far too limited in extent for the new school; indeed the first plan of buildings, campus, etc., submitted by Mr. Emil Swensson, of the Carnegie Steel Co., covered 40 acres and this for not more than one thousand students. The advisory board suggested that not less than 50 acres be secured, and as a tract of 65 acres is available not far distant from the Carnegie Institute, the board strongly recommended its purchase, or a similar piece of land as near by as it is possible to obtain it. A potent reason for placing the technical school near the Carnegie Institute is the fact that its library is rich in technical and other valuable works, which need not be duplicated in the technical school library; indeed the association of the school with the great and increasingly valuable library, museum, art gallery and Academy of Science and Art is certainly to be desired. In this connection it may be well to state that it was the intention of the donor that the city should furnish the land upon which the school of technology should be built, but it is the unanimous opinion of the advisory board that, as Mr. Carnegie not only proposes to build and equip but fully to endow it, it would be far better to purchase the land and thus, while bringing to the city of Pittsburg all the honor such a school of technology would bring, keep it forever free from baneful political influences. Dr. Gray says in summing up his report: "Such an institution properly managed, could in my opinion do much more to advance the science which underlies our industries than any national or State institution is ever likely to do, hampered as all of them are by political association. I may in conclusion express the opinion that for the best work, independence of city or other politics should if possible be insured by avoiding all kinds of public financial support."

As to the buildings for the technical school but little has been suggested; indeed,

this part of the problem, important as it is, may well be left open until the 'scope' of the great work to be done is well in hand. Dr. Thurston in his report has given an interesting résumé of the space occupied by the student in the various German technical schools, remarking that the German motto 'Viel Platz, Viel Licht, Viel Luft,' would be an excellent guide in determining this question. He says: "Ample space, good light and plenty of fresh air are essential, although the architect who should be the most earnest and intelligent of them all is often woefully deficient in appreciation of their importance when brain work is going on." Dr. Thurston further states that taking figures from the best German technical schools, which are based on the largest experience, the school of architecture at Berlin has 150 feet floor space per student, the engineering school 35 feet, but this latter school is so much over-crowded that arrangements are being made to give the student in this department at least 75 feet of floor space. In marine engineering 111 feet are provided and in metallurgy and the chemical departments each student has 426 square feet of space. Professor Thurston advises not less than 30 square feet per student in class rooms, in drawing rooms about 100 and in laboratories from 150 to 500 feet, according to character of the work to be done and magnitude of the space required for machinery and apparatus.

The Brunswick school has 410 feet floor space per student in all departments. At Karlsruhe 450 square feet is provided in the department of electrotechnics. The cost of the Berlin building is placed at $1,000 per student, of the Brunswick buildings $2,000 per student. From this data it can be seen that an institution which may be called upon to provide for a thousand students at once, and perhaps three or four times that number in the near future, must be planned upon a most liberal scale to meet the demands which will be made upon it, and here we shall be confronted with the cost of such buildings. With the knowledge that Mr. Carnegie would not be satisfied with buildings devoid of architectural beauty, I feel morally certain that he would not be willing to invest his millions in buildings not properly constructed for the specific purpose for which they are intended, and with all regard to the society of architects, it is to be hoped that utility will be the first question solved in this important undertaking.

In a recent communication from Dr. Barker, of the University of Pennsylvania, upon this subject he says: "I hope the mistake will not be made of spending too much money upon buildings. The order of expenditure should be as follows: (*a*) Instruction; (*b*) endowment; (*c*) equipment; (*d*) building; by this I mean that the securing of the very best ability in the men in all the departments is an absolute desideratum, not only as teachers but investigators, for technical science is advancing so rapidly that abstract research in pure science cannot keep up with it and so applied science has to enter upon research work to supply the data it needs.

"Next comes endowment. In far too many cases, all the money given has been expended upon building and equipment, leaving nothing for maintenance." Dr. Barker then refers to a number of our noted American universities which have splendid buildings and some of them fine equipment, but with little or no funds to carry on research work. The members of this Association know this fact too well, many of them from unpleasant personal experience. Shall we steer clear of these shoals in the new technical schools?

Brainy men do not need a palace in which to make discoveries. Place a Newton, a Napier, a Faraday or an Edison, a Watt or an Ericson in a hovel and the discoveries

will come whether we will or not. Fortunately we are assured that the man who has given this great technical school for the glorious purpose it is sure to subserve will see to it that the endowment does not suffer; even if the buildings are constructed on a generous scale, but I know it to be his desire that the best technological knowledge shall be united with architectural design, so that the buildings may combine utility with beauty and reflect honor on all associated with the work.

And now as to the scope of the new school. That American schools of technology have done magnificent work for two or three decades goes without saying. Shall the new schools follow in the footsteps of the best of them, shall it unite the best features of one school with the best of another, or shall it venture upon entirely new fields to push outward the borders of human knowledge? The American, German, English, French and Swiss schools have been studied by the members of the advisory board (as well as by some members of our committee), and we have been greatly helped in formulating our plans of what the new school should be, by the generous data given in their report.

A summary of Professor Johnson's proposed scheme for the Carnegie School of Technology is as follows:

A. Colleges. Courses of four years with a high school preparation.

1. College of Science.
2. College of Engineering.
3. College of Commerce.

All the above of university grade, with degrees conferred at graduation.

B. Schools. Courses three years with a grammar school preparation.

1. Manual Training School.
2. Domestic Science School.
3. School of Industrial Design.
4. School of Commerce.

All the above of high school grade. Diplomas given at graduation.

C. Artisan Day School. Courses of three years with a preparation in reading, writing and arithmetic.

To include courses of instruction in subjects of essential importance in the practice of the various trades.

D. Night School for day workers. Preparation same as C.

Regular courses, and also special instructions of practical value to day workers of all sorts and all employments.

Professor Johnson, Dr. Alderson and Dr. Gray studied a number of the industries of our city, and in all their reports they emphasized the value of the secondary schools. The question of monotechnic or trade schools, *i. e.*, where a young man or woman can learn at least the rudiments of the trade by which they propose to make their living, was also discussed by Professor Johnson and Dr. Alderson with the writer, and it is the opinion of both committee and advisory board that in due time this part of the problem should be given earnest consideration. A summary of Dr. Alderson's recommendations as to the various departments that could advantageously be established in the school are:

First—Department of Engineering, comprising

(*a*) Mechanical Engineering.
(*b*) Electrical Engineering.
(*c*) Civil Engineering.
(*d'*) Chemical Engineering.
(*e*) Electro-chemical Engineering.
(*f*) Foundry Practice.
(*g*) Metallurgy (iron and steel).

Second—Department of Secondary Education.

1. Work preparatory to the College of Engineering.
2. Secondary Technical Education.

Courses in

(*a*) Machine Tool Work.
(*b*) Stationary Engineering.
(*c*) Elementary Electrical Engineering.
(*d*) Elementary Mechanical Engineering.
(*e*) Foundry Practice.
(*f*) Surveying.
(*g*) Drafting.
(*h*) Machine Design.
(*i*) Glass Making.
(*j*) Blacksmithing.
(*k*) Pattern Making.

(*l*) Brass Making.
3. Department of Library Economy.
4. Department of Domestic Arts and Sciences.
(*a*) Normal Course.
(*b*) Courses in cooking, sewing, dressmaking, millinery and household economy.
5. Department of Art.
6. Department of Evening Instruction.

Dr. Alderson closes his summary with these words of sterling advice: "The Carnegie School of Technology should be a protest against *surface education;* it should educate the hand and eye as well as the mind; it should emphasize the *doing* element in education; it should be essentially a school of applied sciences; and finally it should enter the broad field of technical education, supplying useful knowledge to boys and girls, young men and young women. The Carnegie School of Technology, located in a center of industrial activity, on grounds naturally beautiful and attractive, carefully planned and thoughtfully administered, can be made to bear the same relation to the great work of technical education that Columbia College does to university education, and thus become a technical school second to none.

Dr. Gray recommends that the institute should offer a course of instruction covering the whole nine years of study; that it be divided into two distinct schools, a secondary and upper secondary, and a higher college or professional school. He advises that the secondary school commence above the grade schools with a minimum age limit of 14 years, and that the course of instruction should include all the subjects commonly given in the best high schools, with the possible exception of Latin and Greek, and in addition the subjects more commonly given in business schools or colleges; along with this course of class room instruction, provision should be made for practical instruction, either manual or otherwise, bearing upon the particular branch of industry which the scholar intends to enter. The duration of this course should be about four years, as at present in city schools, but should be freed from a number of subjects that are of little use to the ordinary artisan class. Dr. Gray recommends a good sound course in English for students of the secondary school, but does not recommend a study of foreign languages.

One of the most important, if not the most important, recommendations made by Dr. Gray is that in regard to the upper school. I quote his language:

"This school can be made to fill the place which the present technical colleges have failed to do, namely, provide a college education for men of the rank of shop foremen, superintendents, etc. In this course, which should be of two years' duration, instruction can be given in such subjects as the design of structures and machinery, the properties of materials and machines, the design and management of power stations, telegraphy, and train signal systems, the surveying and construction of railway beds, civil engineer's and architect's office work, finer kinds of machine work and a host of other subjects, the understanding being that these subjects be treated in such a manner that *practical* information shall be the object rather than fundamental mathematical principles."

Other matters of importance are suggested in this part of Dr. Gray's report, one of which is that as there would probably be those in this course who would find it impossible to take the higher or technical college education, this upper secondary school would serve as a most excellent preparation for the same.

Dr. Gray recommends that the technical college or professional school be open only to a selected small number of students who have shown special fitness for the work, and that the entrance requirements should be considerably higher than is usual in existing

technical colleges. For this department extensive laboratory practice is recommended and thorough drill in the methods of testing properties of matter and in investigational work. Dr. Gray—as indeed every member of the advisory board—thoroughly agrees with Dr. Barker that apparatus should not be merely toys, that they must subserve some real purpose in the activities of life. As Dr. Barker puts it: "Where shall we draw the line between a testing machine and a cohesion apparatus—between a calorimeter of a pint capacity (an apparatus) and one of 100 gallons (a machine)," etc.

Dr. Gray suggests that this course might be of three years' duration and that fees be charged. Deserving students unable to bear the expense could possibly be provided with scholarships. Original research should be a prominent feature in this higher college.

Dr. Thurston's report to the committee is an exhaustive one, covering every phase of technical education, and as the commission will have it printed in full with the reports of other members of the board, I shall only give a few of the salient points in his paper.

Dr. Thurston assumes that the purpose of the institute will be primarily the useful education and technical training of the young people of Pittsburg, and especially of those belonging to the great body of wage earners, and that both sexes are, if practicable, to be equally well cared for. He divides these into two classes: (*a*) Those who can come to the instructor and give their time as required to study, to lectures and to recitations, and (*b*) those who are compelled to work during the working hours of the establishments in which they are employed and can only be given instruction outside during the evening hours, usually in evening classes.

Dr. Thurston asks: "Is it practicable to carry into effect that ambition of every technical education, so admirably pictured by Scott Russell, 'the Technical University on the lines of which Ezra Cornell would have approved, where any man could secure instruction in any study in such departments as are capable of being utilized practicably in the sequel of life. It is obvious that could such an institution be founded, and thus the noble example be furnished in full perfection, and a standard thus provided by which to measure, the establishment of this complete and perfect model would, very probably, advance the cause of useful education of the people, for the life and work of the people for many years. It is possible that the opportunity is here and now presented, and that, lost, it may not recur again.'"

The opportunity is one not simply to provide education of the most imperatively needed sort for the youth of Pittsburg, but it is an opportunity to establish a model of the most perfect and most widely useful institution of learning that has been conceived, and that shall, by force of example establish a standard and promote the most complete and perfect system of technical and liberal education anywhere.

The general scheme laid out for the great technical school by Dr. Thurston is as follows:

(*a*) The college of mechanical engineering and the mechanic arts, with eight different departments of mechanical engineering.

(*b*) The college of civil engineering—with six departments.

(*c*) The college of architecture with three departments.

(*d*) The college of mines and metallurgy with two departments.

(*e*) The college of agriculture with six departments.

(*f*) The college of applied chemistry with four departments.

(*g*) The college of physics with two departments.

(*h*) The college of fine arts with three departments.

(*i*) The college of the business man with four departments.

(*j*) The college of navigation and marine transportation with two departments.

(*k*) The college of mathematics with two departments.

(*l*) The college of politics and economics with four departments.

(*m*) The college of languages and literature with four departments.

(*n*) The college of philosophical science and ethics.

(*o*) The college of biology.

(*p*) The preparatory college (standard curriculum).

"This scheme appears an ambitious one, but it so appears simply because we are in the very inception of educational work, and few persons have the slightest idea of the need or the opportunity for promoting the highest interests of the nation through a thoroughly systematized education."

Dr. Thurston refers with just pride to the Massachusetts Institute of Technology, the Armour Institute, the Pratt and Drexel institutes, as well as to others of a similar character, giving the curriculum of that sterling school of technology, the Massachusetts Institute, as well as much valuable data regarding the faculty, equipments and graduate students, all of which is compared with the Royal Technical College at Berlin. Dr. Thurston, with every other member of the commission, lays particular stress upon the value of the secondary school which he chooses to call the technical high school and which it is evident will meet the needs of the largest number of people. He chooses for a typical illustration of this division of the scheme the splendid work of the Pratt Institute of Brooklyn. Dr. Thurston also emphasizes the great value of such a secondary school to the young men and women of Pittsburg particularly, and believes it is only carrying out Mr. Carnegie's wishes to develop this department to its fullest extent.

As to the higher departments of the new school he expresses himself most charmingly in the language of John Russell on the occasion of the latter's visit to a German technical university: "A technical university abroad was to me a surprise, a profound lesson, a delight. It was a dream of my youth suddenly embodied in living substance, and, unlike other realized dreams, the reality excelled the fiction. It was one of my early dreams that highly educated men should engage in teaching skilled workmen the profound philosophical principles which underlie all material work, and I hoped so to make their work their pleasure, excellence their ultimate aim and truth of execution and perfection of finish their highest ambition."

Dr. Thurston proceeds to discuss the higher branch of technical education with special reference to the needs of Pittsburg, then gives us some valuable information as to the status of the faculty of the great school, quoting precedents in home and foreign institutions. Endowments are also discussed with a freedom that has opened our eyes to the vital importance of this part of the scheme, and to which I have already referred in this paper. Summarizing, Dr. Thurston says:

"The first step considered advisable in preparing to supply Pittsburg and its environs with an institution of high efficiency for technical instruction should be to make a plan of that final educational structure which is taken to represent the limit toward which progress is expected to advance. The actual construction of the scheme should be commenced with the most essential elements; the less immediately and imperatively needed parts should be arranged for later. In the present case it would probably be justifiable to assume that the aim of the school should be, first, to provide for the young people of Pittsburg needing elementary technical educational instruction, and to organize for this purpose a technical high school with evening classes for pupils unable to attend regularly the day classes. This foundation being laid,

the various developments which have been considered in the preceding pages may be added, each as the preceding element is completed, working continually toward the technical university and the highest ultimate divisions of the scheme, the department of experimental engineering and research.

"The method of organization would be that which best insures the management of the whole of the great scheme and of each of its subdivisions by men expert each in his own field, whether that of director of the technical university, principal of one of its schools, or professor or instructor, or workman in shop, drawing-room or laboratory. Such an organization of a staff of experts being provided, the administration will be certain to work smoothly and efficiently, without special attention to detail on the part of the trustees. Their largest problem will be the matter of securing the endowment and its income from deterioration in later years and consequent impediment or interruption of the enterprise.

"Every division of the institution, from lowest to highest and first to last, should be so planned as to work in concert with the public schools of similar grade as far as practicable. The technical high school might accept certificates from the academic high schools of the city and from other academies of similar rank; the pupils of the city schools might be given admission to the classes of the technical school in the shops and technical departments; a half-time school, as advocated by Professor Higgins, of Worcester, might possibly come of such mutual aid of city and technical schools. The technical school would be able, in some cases probably, to promote the initiation of special instruction in manual training and in the kindergarten forms of technical work in the public schools. Every possible means of allying the technical and the common school work should be availed of, and the cardinal principle should be constantly proclaimed and enforced: the purpose of the whole movement is to advance the best interests of the people of Pittsburg and its vicinity. It should be made distinctly understood that it is desired to make use of all possible ways to that end and to cooperate with every other educational movement."

In closing this far too lengthy paper I must acknowledge the great interest taken in the development of the scheme for the new technical school by the Engineers' Society of Western Pennsylvania, by the Women's Domestic Arts Association and by a number of eminent engineers, physicists and technologists at home and abroad; and the sole purpose of my paper is to ask the further cooperation and kindly advice of the members of this Association in formulating our plans, in steering clear of 'derelicts' and in making the Pittsburg Carnegie School of Technology what its generous patron wishes it to be and what the demands of this great industrial nation require it to be. Any communication sent Mr. Wm. McConway, chairman of our committee, Pittsburg, Pa., will be received and acknowledged with great pleasure.

J. A. BRASHEAR.

SECTION A (MATHEMATICS AND ASTRONOMY) OF THE AMERICAN ASSOCIATION.

THE officers of this section were: vice-president, James McMahon; secretary, G. A. Miller; councilor, G. B. Halsted; sectional committee, James McMahon, G. A. Miller, H. A. Howe, Florian Cajori, F. H. Loud; member of the general committee, C. A. Waldo. The meetings of the section were well attended and most of the papers aroused discussion. With the exception of the anniversary meeting at Boston, the program was the most extensive in the recent history of this section. It consisted of the following twenty-five papers. As