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.

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MSS. intended for publication and books, etc., intended for review should be sent to the Editor of SCIENCE, Garrison-on-Hudson, N. Y.

THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

SECTION D—MECHANICAL SCIENCE AND ENGINEERING.

THE work of Section D of the American Association for the Advancement of Science is in mechanical science and engineering. The section devotes itself to showing the advances which recently have been made in the principles and applications of science in regulating and using the forces of nature. The papers which are presented usually deal with what are commonly known as the applied sciences, more particularly with those which are based upon physics and chemistry. Under electricity are included its generation, adaptation and use on a commercial scale. Under heat are included such practical questions as the generation and use of steam. Under chemistry are included the combustion of coal and other fuels, and the production and use of gas for heating, forging and annealing, and for the generation of power in gas and oil engines; while in the allied science of metallurgy the problems of the mining engineer and metallurgist of iron and steel are included. Under hydraulics we find a long list of problems, the advancement of which has been rapid in recent years in the utilization of the results of the work of the sun as a heat agent, and in controlling this same transmuted heat energy when it manifests itself in swollen streams.

The section is to be congratulated on having had as its chairman Vice-President Calvin M. Woodward, of St. Louis, who is well known in that city as professor of applied mathematics at Washington University, and as the originator of the St. Louis Manual Training School. Throughout the country he is equally well known as 'the apostle of manual training' and as one of the leading educators of the world; his reputation and position in the community enabled him to be a most efficient vice-president.

Professor J. Burkitt Webb, of Stevens Institute, at Hoboken, N. J., was elected as councilor, and Professor George W. Bissell, of Iowa State College of Agriculture and Mechanic Arts, Ames, Iowa, was elected a member of the general committee. Professor William Kent, of Syracuse University, Syracuse, N. Y., was elected member of the sectional committee for five years. The sectional committee consisted of Professor Clarence A. Waldo, Purdue University, Lafayette, Ind., vice-president 1903; Mr. Elwood Mead, Department of Agriculture, Washington, D. C., secretary, 1903; Professor Calvin M. Woodward, Washington University, St. Louis, Mo., vice-president, 1904; Professor W. T. Magruder, Ohio State University, Columbus, Ohio, secretary, 1904–8; Professor Mansfield Merriman, Lehigh University, South Bethlehem, Pa.; Professor J. Burkitt Webb, Stevens Institute, Hoboken, N. J.; Professor H. S. Jacoby, Cornell University, Ithaca, N. Y.; Professor H. T. Eddy, University of Minnesota, Minneapolis, Minn., and Professor William Kent, Syracuse University, Syracuse, N. Y.

VICE-PRESIDENT'S ADDRESS.

The vice-president's address was delivered by Professor Clarence A. Waldo, professor of mathematics at Purdue University, Lafayette, Ind., on the subject of 'Engineering and Mathematics.' It was a statement of the great influence of the engineering colleges upon the teaching of mathematics, and was a strong plea for the rationalization of mathematics and especially for engineering students, and also for illustrating the reality of mathematical formulæ and expressions by examples drawn from engineering practise. By this means it will be found that the student will perceive the utility of mathematical applications earlier in his course, and will not be studying the subject for reasons of either blind faith or stolid obedience. As the paper has already been published in the columns of SCIENCE, we gladly refer the reader to the address itself.

EXCURSIONS.

The section met for the presentation and discussion of papers on Tuesday, Wednesday and Thursday mornings and on Wednesday evening. Tuesday afternoon was spent in an excursion under the auspices of the St. Louis Engineers' Club, to the Eads Bridge, and by special train to the Union Station to inspect the changes now being made in its terminal facilities. The members of the section availed themselves of the kind invitation of the managers of the Louisiana Purchase Exposition, and visited the exposition grounds on Thursday afternoon, where, after luncheon, they inspected the extensive buildings and grounds, and the machinery which was being installed.

PAPERS.

Professor A. S. Langsdorf, of Washington University, presented a paper giving 'Graphic Methods for Determining the Equations of Experimental Curves' and giving means for fixing upon the type of equation to be used and of evaluating the constants of an equation which represents a curve found experimentally. Parabolic, hyperbolic, logarithmic and periodic curves are treated by his method. The paper will probably be published in the *Journal of the Association of Engineering Societies.*

Professor J. L. Van Ornum, of Washington University, St. Louis, Mo., described the results of his experiments on 'The Fatigue of Cement Products.' In his experiments he made tests of cubes and prisms of neat Portland cement, and of concrete, applying different loads at the rate of about four times per minute until rupture ensued, and plotting a curve of results showing the number of repetitions necessary to cause rupture when the load was a given per cent. of the ultimate static strength. The results of the tests of cubes of neat cement show that repeated loads, less in intensity than the ultimate strength of the material, will cause failure. The number of repetitions necessary to produce this effect increases very rapidly for loads less than 65 per cent. of the ultimate strength, and seems to become infinite at about 50 per cent. value. For example, 180 repetitions of the load of 80 per cent. of the ultimate static strength are sufficient to cause rupture. Four hundred repetitions of the 70 per cent. load, or 1,000 repetitions of the 62 per cent. load, or 1,700 repetitions of the 60 per cent. load, or 4,000 repetitions of the 56 per cent. load, or 5,000 repetitions of the $55\frac{1}{2}$ per cent. load, will do the same. The same general law applies equally to concrete. The above results with cement and concrete are, therefore, similar to those obtained by Woehler on iron and steel. The modulus of elasticity of cement and concrete is greatly reduced in value under the influence of repeated loads of the intensities indicated. Prisms $5'' \times 5'' \times 12''$ high were used in this work. The paper will be printed in *The Transactions of the American Society of Civil Engineers.*

A paper on 'The Design of Steel Concrete Arches,' by Professor E. J. McCaustland, of Cornell University, Ithaca, N. Y., was read in his absence by his colleague, Professor H. S. Jacoby. The author calls attention to the lack of clean-cut, definite knowledge as to the action of steel combined with concrete under stress, and particularly in an arch ring subject to moving loads, and states that arches are built with factors of safety ranging probably all the way from 3 to 150. He is of the opinion that we do not so much need new theories as we do an extension of our practical knowledge of the mechanical properties of concrete. He gives an abstract and discusses a graduating thesis on the subject by Mr. W. S. Edge. After briefly stating the theory which formed the basis of the investigation and describing the details thereof, he summarizes Mr. Edge's conclusions as follows: (1) that the graphic method of solution is as accurate as is justified by our knowledge of safe unit stresses in concrete; (2) that an arch ring designed for thrusts due to uniform live loading will be too thin at the haunches to resist stresses due to eccentric loads; (3) that in large spans it is more accurate to use Cain's method of subdividing the arch ring, since it gives, in general, results for thrusts which are about two per cent. greater than will be given by dividing the arch into equal horizontal sections; (4) it is better not to try to use a modified semi-ellipse for an earth-filled arch when the rise is less than one sixth, or possibly one eighth of the span, as the equilibrium curve flattens it too much at the haunches. It is better to take full advantage of the rise by making the arch linear from crown to springing, thereby reducing the crown thrust. (5) The maximum bending moment is not produced by a live load covering one half of the bridge. For the crown section the bending moment is the greatest when the load is about three fifths on the bridge. The greatest positive moment, however, occurs with the arch practically one half loaded. The greatest negative moment occurs when the arch is three fifths loaded. As the result of designing about fifteen arches, Mr. Edge suggests a method of procedure which he has found to be the most simple, and hopes that some one else will be interested in extending the investigations. The paper will probably be published in the *Transactions of the American Society of Civil Engineers.*

Professor Henry S. Jacoby then gave an account of 'The New Features and Tendencies in Bridge Engineering' which he had observed in his very extensive bridge inspection tours which he has had the privilege of taking during the sabbatical period which was granted to him by Cornell University. He noted the increase in the use of plate girders up to those of 128 feet 4 inches from center to center of supports; that the present tendency in railroad bridge construction seemed to be to get rid, so far as possible, of the overhead portions of bridges; that riveted trusses were now built in spans up to 230 feet; that the length of panels had now been increased to 37 feet, and mentioned bridges over the Monongahela and Allegheny Rivers of the Pratt type, with curved upper chords having only 11 panels in 417-foot spans. The maximum span of simple trusses is still the same as it was ten years ago, the record being held by the Louisville bridge of 546 feet 6 inches. The Pratt truss seems to be in the ascendency in both riveted and pin construction. The author stated that the majority of the masonry now being constructed by the railroads, with one notable exception, is of concrete, and that concrete arch bridges had been built with spans up to 130 feet. Professor Jacoby has evidently improved his opportunities during the past year, and his work as an instructor must of necessity be correspondingly benefited by the opportunities which he has accepted for studying bridges in the drawing-room, in the shop, in the field and in use.

The next two papers presented were from the Ohio State University, at Columbus, Ohio. The first one was by Professor Wm. T. Magruder, and described 'An Hydraulic Micrometer Caliper' which was presented for inspection to the section. This caliper consists of a bronze graduated circle sixteen inches in diameter which is secured to the end of a hydraulic drum connected to a stand-pipe, and so that it can be rotated around its axis. Cross-screws, both radial and axial, are carried by the revolving ring so that pointers fixed in the ends of the axial screws can be brought into contact with the surface of a jet of water issuing from the orifice, and so that by means of a scale on the screws all the coordinates of the jet can be obtained for a distance of six inches or more from the entrance to the orifice.

Professor James E. Boyd and Professor Horace Judd presented a paper describing and giving the results of their experiments with 'Pitot Tubes,' and on 'The Experimental Determinations of the Forms of Water Jets.' The paper describes "a Pitot tube as a simple contrivance for measuring the velocity of water. It consists of a small tube placed in the stream so that the water strikes fairly against one end. Some distance from the end it is bent and connected to a vertical glass tube. The current striking against the end produces a pressure which is measured by the height to which water rises in the glass tube (or, in case of high pressures, by a gauge of some sort). Pitot claimed that this height was equal to the distance a body must fall to acquire a velocity equal to that of the stream. Later observers have thought that this is incorrect, and that the water rose much higher. These experiments were with jets, and showed that Pitot was practically correct. Incidentally it was found that the contracted vein in a jet of water from an orifice in a thin plate is about .785 of the diameter of the orifice, and that the velocity of such a jet is over 99 per cent.

of the theoretical velocity. The paper describes experiments to determine the constants of Pitot tubes. Tubes with variously formed tips and of inside diameters ranging from .162 inch to .007 inch were placed in the jet from an orifice in a thin plate. Each tube gave a pressure practically the same as that in the drum, from which the water was flowing. No change was observed when the tubes were moved back and forth along the axis of the jet, the increase of static pressure back of the plane of the orifice exactly compensating for the diminution of velocity pressure. To determine the velocity of the jet, measurements were taken of the coefficient of contraction, the coefficient of discharge, and of the relative velocities at different distances from the axis of the jet. The mean velocity from a two-inch orifice was found to differ from that in the center by less than .0002. The coefficients were:

Orifice.	Coefficient of Contraction.	Coefficient of Discharge.	Coefficient of Velocity.
2 inch.	.6162	.6112	.992
1.5 inch	.6115	.6119	1.001

As the velocity was practically the same in all parts of a section, the figures for the coefficient of velocity represent the constants of the Pitot tubes, which give readings equal to the static pressure behind the orifices. Similar measurements were made with a short pipe from which the coefficient of the Pitot was found to be .993.'' The hydraulic micrometer caliper described in the preceding paper was used in making the above measurements.

Professor J. Burkitt Webb, of Stevens Institute, Hoboken, N. J., presented a paper on 'Molecular Velocities,' in which he offered a simple illustration in support of Maxwell's theory that the only permanent state for the molecules is one in which the velocities are not the same for all molecules, but that all possible velocities must be supposed arranged according to the law of probabilities. ''Suppose a number of small elastic spheres of equal mass moving in all directions with equal velocities, and consider two of them moving at right angles to each other, and so that sphere B strikes sphere A at the instant that the center of A crosses the path of B, the velocity of A in the direction of B's motion is zero, and therefore all of B's motion will be transferred to A. This will increase the velocity of A from v to $v\sqrt{2}$ Evidently another rectangular blow from a sphere C would increase this velocity to $v\sqrt{3}$, and so on, so that we have in this a proof that an equal distribution of velocities would not be a permanent one, and that the final permanent distribution must depend upon the possibilities of the various phases of collision that may occur.''

Professor G. W. Bissell, of Iowa State College, Ames, Iowa, presented a paper on 'Iowa Coals.' He stated that the Iowa coal fields have an area of 20,000 square miles, and include the southwest one third of the state. The Des Moines valley mines are the most active. In this district coal is found at depths of from 100 to 300 feet in veins from 18 inches thick and upwards. The thinner veins are profitably worked in conjunction with the manufacture of brick and other clay products made from the coal shales. Iowa coals are mostly bituminous and non-coking. The average proximate analysis gives:

Moisture	8.08	
Fixed carbon	45.60	
Volatile	38.14	
Ash	8.18	100.00
Sulphur	3.42	

The calorific power of Iowa coals as determined at Iowa State College with the Parr calorimeter ranges from 9,180 to 13,141, with an average of 11,780 B. T. U. per pound of oven-dried coal. From a number of proximate analyses of Iowa coals, and from determinations of their calorific value by means of the Parr calorimeter, he deduced the formula that the calorific value of an Iowa coal $= (14{,}600C + 12{,}180V + 4{,}000S) \times .01$ B. T. U. The following table gives the results of boiler tests made with Marquisville (Iowa) coals of different sizes, with coke and anthracite nut, and is of interest in showing the prohibitive price of anthracite, and that the fuel cost of generating steam with slack coal is from 30 to 40 per cent. less than the fuel cost with lump, nut or steam coal in the same mine.

Kind of Fuel.	Cost per ton of 2,000 lbs.	Fuel cost of 1,000 lbs. steam from and at 212°.
Marquisville, Slack....	$1 43	14.9 cents.
Steam....	2.35	21.2 "
Nut......	2.54	21.5 "
Lump....	2.88	24.0 "
Coke, Eastern Foundry.	8.00	60.4 "
Anthracite Nut........	8.95	52.8 "

Following in this line came a paper by Professor C. H. Benjamin, of the Case School of Applied Science, Cleveland, Ohio, on 'The Science of Smoke Prevention.' As Professor Benjamin was for several years the engineering expert in enforcing the ordinance against smoke production in Cleveland, his conclusions are the result of both scientific attainment and practical experience in dealing with the smoke question in cities. They are as follows: (1) That objectionable smoke from soft coal can readily be prevented; (2) that such prevention will result in a higher efficiency and smaller fuel bills; (3) that all new plants should be subject to permits issued by proper city officials; (4) that educational and legal measures combined should be used in cases where the evil already exists; (5) that the control of such work should be in the hands of properly trained engineers who understand the whole subject thoroughly; (6) that the people of each community must see to it that they are protected from this evil as from poor drainage and dirty streets.

Professor William T. Magruder, of Ohio State University, Columbus, Ohio, presented a paper entitled 'A Producer Horse Power—A Proposed New Unit.' After reviewing Watt's unit for a boiler horse power, and that adopted by the Philadelphia Centennial Commission, he stated that the rapid introduction of the use of gas-engines using blast-furnace gas or producer gas leads to the suggestion of a unit for the horse power of a gas producer similar to the unit for the horse power of a boiler. As some gas engines are now delivering a brake horse power for the generation of 10,000 B. T. U. per hour, and a few are doing 10 to 15 per cent. better than this, he suggested as a proposed new unit that of a 'producer horse power.' He defined it as 'the generation in an hour of sufficient gas at 60° F. to produce 10,000 B. T. U. when burned to water and gas at 60° F., or its equivalent.'

Before availing itself of the invitation of the St. Louis Engineers' Club, the section listened to a paper by Mr. A. P. Greensfelder, assistant engineer of the Terminal Railroad Association of St. Louis, on 'Recent Improvements at the Union Station at St. Louis.' The paper was illustrated by the plans for the improvements which are now under way, showed the necessity for them for handling the passenger and freight business of St. Louis, and described in some detail the methods which had been adopted for changing the tracks and moving all the express company buildings, while operating over 1,100 passenger cars each day. Incidentally, the paper showed the advances which have been made in terminal railroad facilities by the use of applied science.

AERONAUTICS.

The program for Wednesday morning was made up of a series of papers on problems connected with aeronautics. Professor J. Burkitt Webb, of Stevens Institute, Hoboken, N. J., presented two papers. One was on 'The Flying Machine Problem,' in which he showed among other things that 'for rapid flight a considerable altitude is favorable.' The second one was on 'Practical Artificial Flight.' The author stated that the inventor should aim for the most practical results and should attack the main difficulties at the start. To this end, he suggested that the question of motive power be eliminated, and that power be supplied from a trolley or from an overhead source, and that the endeavor should be to develop a machine which can slowly and surely rise from the ground and as slowly and safely descend again; and which should be controlled by an automatic balancing device.

Mr. A. Lawrence Rotch, director of the Blue Hill Meteorological Observatory, Hyde Park, Mass., read a most interesting paper, which was illustrated by the stereopticon, descriptive of the 'Exploration of the Atmosphere as Practised with Kites at the Blue Hill Observatory since 1894.' The methods employed and the results obtained are in part described in the appendix of the 'Smithsonian Report' of 1900, and the later technical details will be published in the *Annals of Harvard College Observatory,* Part III. of Volume XLIII.

'The Aeronautical Contests at the World's Fair, St. Louis, 1904,' were outlined and discussed in three papers presented by Professor Calvin M. Woodward, Washington University, St. Louis, Mo., Mr. A. Lawrence Rotch, director of Blue Hill Meteorological Observatory, Hyde Park, Mass., and Mr. Willard A. Smith, chief of the transportation exhibits, and in charge of the Department of Aeronautics, of the St. Louis World's Fair. All three gentlemen are members of the committee having the subject in charge. Professor Woodward introduced the subject. Mr. Rotch described and illustrated with the lantern the most successful dirigible balloons and flying machines, some of which are likely to be tried at St. Louis, and discussed the regulations for these experiments as drawn up by the committee. Mr. Smith continued the subject, discussing it in detail, and describing the facilities which would be offered to contestants for inflating their balloons with hydrogen gas, 97 per cent. pure, made by a new English process, which is guaranteed to deliver 25,000 cubic feet of hydrogen for the combustion of one ton of slack coal. The method of generation, it was stated, will consist of the dissociation of steam by incandescent iron shavings, and the revivification of the oxide of iron so formed by producer gas.

The last paper of the morning was by Mr. Octave Chanute, on 'Aerial Navigation,' and was a most able one. After calling attention to two probable solutions of the problem, he described what has been accomplished with balloons and flying machines, the evolution and limitations of such apparatus, their limited uses, and discussed the prospect of any one winning the prize offered by the World's Fair Commission. It is published in the March *Popular Science Monthly.* The series of papers being by noted specialists of high scientific attainments were greatly enjoyed by all those who availed themselves of the privilege of hearing them.

THE HYDROLOGY OF THE MISSISSIPPI RIVER.

The Wednesday evening program included in its scope the entire Mississippi River Valley, beginning with a paper by Professor C. W. Hall, of the University of Minnesota, at Minneapolis, Minn., on 'The Stream Flow of the Upper Mississippi

River' and ending with a paper by Mr. James A. Seddon, of St. Louis, on 'The Lower Mississippi River.'

Professor Hall's paper was illustrated by a number of lantern slides showing the head-waters of the Mississippi, the geological formations of the valley and a study of the currents and the flow of the waters of the river.

A paper by Judge R. S. Taylor, of Ft. Wayne, Ind., a member of the Mississippi River Commission, was then read on 'Levees, Outlets and Reservoirs.' He stated that the alluvial valley of the river below Cairo contains 29,790 square miles of lands subject to overflow in its natural state; that it is all capable of protection and reclamation by levees, which has been going on for nearly 200 years, except a small area at the foot of each drainage basin, which has to be left open for the escape of surface drainage. The existing lines of levees are about 1,350 miles long and about 80 miles remain to be constructed to complete in length the main river system. In few places, however, are the embankments as high and as strong as they should be for the greatest safety. 'The potential high water of floods to come' has been the subject of much study and discussion. The nearest approach to a standard has been that the levee should be three feet above the highest previous flood line in that locality.

The flood of 1897 made 38 crevasses having an aggregate width of about 8 miles; the flood of 1903 made 9 crevasses, having an aggregate width of about 3 miles. The levees in place in 1903, if no crevasses had breached them, would have protected about 26,000 square miles from overflow. Of that area a total of about 3,000 square miles was overflowed in consequence of the crevasses which took place, which is less than one eighth of the entire area which the existing levees could and would have protected if they had all been high enough and had held their places. In the phrase of the target-shooters, they accomplished $87\frac{1}{2}$ per cent. of success out of a possible 100. The levee system is at this moment in the very crisis of its history. It has demonstrated the possibility of its usefulness. It wants just the last grand effort to carry it to completion. We ought not to think of the diversion of any part of our resources to any other work while that remains unfinished. During the flood of 1903 the existing levees protected from overflow seven eighths of all the lands capable of protection. If great floods should come once in five years, and we should never do any better than we did last spring, this would mean that there would be an average annual inundation of $2\frac{1}{2}$ acres out of every 100 acres. This would seem to show that the present system of levees is successful. The author does not believe in the successful protection by outlets and reservoirs, and paid their advocates the compliment of a polite refutation of their arguments. The paper will be published by the Werner Co., Akron, Ohio.

He was followed by Professor Lewis M. Haupt, of Philadelphia, Pa., who referred to the law of 1879 and to reports of the 'Board of Engineers.' He quoted the resolution of congress of 1891 that 'no portion of the appropriation then made should be expended to repair or build levees for the purpose of reclaiming land, but only when it may afford ease and safety to the navigation and commerce of the river and deepen the channel. He stated that it was shown, by a comparison of surveys made at an interval of twelve years, that the bed had risen about four feet, and that the banks above low water had caved in to a large extent. He urged that the law be amended so as to provide for specific appropriations for levees to protect the waste and swamp lands, which, he claimed, were quite as deserving of national aid as the arid lands of the plains. He advocated a more thorough system of drainage by the removal of the obstacles and bars in the section below Red River. He discussed the statements made as to the effect of crevasses, showing from surveys that they are of great benefit in reducing the flood stages and improving navigation, as well as in adding extensive tracts to the arable lands of the state and nation. By removing a large percentage of silt from the river, they also retard the gulfward movement of the bars and flatter slopes which contribute to flood heights. By the natural process of hydraulic grading not less than 150 square miles have been deposited above the gulf level within thirty years. To have filled this up by dredges at ten cents per yard would have cost $1,500 per acre, which would have been prohibitory. He also dwelt on the need of removing bars from the front of all passes, by a curved form of jetty, simulating and applying the action of all streams in creating the deep-water pools found in their concave bends. Thus vessels could freely navigate all the passes, while at the same time the floods would be lowered and the sediment be deposited on the opposite or convex bank.

Colonel J. A. Ockerson, of St. Louis, with the aid of stereopticon illustrations described the work of the Mississippi River Commission, of which he is a member. He discussed some of the physical characteristics of the river and the subjects of flood control and channel improvement, and showed scenes along the river from its source to its mouth, including the levees and levee building, crevasses, and the hydraulic dredges used in the channels and the methods of removing obstructions to navigation.

The last paper of the evening was on 'The Lower Mississippi River,' by Mr. James A. Seddon, of St. Louis, Mo. He stated that the word 'river' is a geographical and not a physical term. That, unlike the tidal rivers, the Mississippi is a power that has made its valley and is master of it. The great flood has more than ten times the power of Niagara in its flow to the gulf. He discussed in considerable detail the physical conformation of the valley, showed that the river has an excess of power to carry its sediment, and stated that the only place where the Mississippi River has formed a bar by dropping this sediment is where it meets the waters of the gulf. At the mouth the flow can no longer carry its sediment, as it is too weak. In the valley the flow is too strong and it chokes itself up and spreads out in shallows. He discussed the subject of dykes and bank protection and gave many interesting facts concerning levee history. The author is in favor of a reservoir system of protection, and stated that this would give the bottom lands a certain flood protection, while emptying the reservoirs at the time of low water in the river would triple its depth, and the cost of the work of reservoir construction would have been a little more than half of the $80,000,000 which has been spent on the lower Mississippi. By this means the river would become a deep waterway which would not stop at the Ohio River, but continuing up the Illinois River through the Chicago drainage canal, would join the lake and gulf commerce. He is of the opinion that what is most needed in this case is a statesman to see 'that the river and harbor bill carries a responsibility that will produce results with its expenditure.'

This series of papers gave as complete a résumé of the subject as the time allotted would permit, and showed what a wide diversity of opinion there is among scientific experts on this extremely important problem in civil engineering and hydraulics.

The Thursday morning program was, as

usual, well filled with several papers which had been left over from Tuesday, and with the remaining papers of the program. One of these was by Professor Frank B. Williams, of Union College, Schenectady, N. Y., on 'Methods of Determining the Coefficients of Elasticity.' By loading a beam supported at its ends at two points equidistant from each other and from the ends, and thereby eliminating the cross shear, the coefficient of linear elasticity can be determined by measuring the deflections. Knowing E, the coefficient of elasticity for shearing is obtained by the formula given by Professor Merriman.

General E. W. Serrell, of West New Brighton, N. Y., followed with a paper on 'A Proposed Method of Building the Mandingo Ship Tunnel,' through the Cordillerian range of mountains in Central America, where the distance from sea to sea is but twenty-nine and one half miles. The Gulf of San Blas and the magnificent harbor of Mandingo are at the north end, while directly south, behind the Pearl Islands, within the Bay of Panama, is another harbor. The mountain range averages about 1,520 feet high. The proposed ship tunnel is to have portals 300 feet high. The length of the crown of the tunnel will be less than five miles. Instead of the shales found in the lines of the two other proposed routes for ship canals across the isthmus, the geological formation at this point has been investigated by an expert geologist, who states that the rock extends across the isthmus, that it is very uniform, strong and in every way suited for tunneling. Tested at the Watertown Arsenal, it was found to be stronger than Quincy granite. Analyzed at the geological laboratory at Washington, it was found that hornblende predominated in the granite. The canal-tunnel will be a straight line from sea to sea, and therefore capable of passing a ship of any length. The paper discussed the elements of the cross-section of the tunnel, the method for its construction, using three headings and understoped as well as open benches, and nine overhead tracks to remove the debris, and it is stated that the 18,000,000 cubic yards in the tunnel and the 37,000,000 cubic yards of excavation outside the tunnel can all be made for less than $100,000,000. It is estimated that the work can be completed in two years, although three years have been allowed.

Considering its good geological position, the excellence of the harbors available, the abundant supply of water at sea-level, no locks to delay passage of shipping, and more than ten times the capacity for business, as compared with any other proposed isthmian canal, it would be cheap at three or four times the cost, to say nothing of the short time which will be required to build it.

Before adjourning on Thursday to enjoy the hospitality of the officers of the World's Fair, the section had the privilege of listening to Lieutenant G. L. Carden, U. S. Revenue Cutter Service, on 'Some Topics Connected with the Machinery Department of the World's Fair.' The author is superintendent of 'arsenal tools' in the department of machinery at the fair, and was sent abroad and secured many of the foreign exhibits of machinery.

The section chose Professor David S. Jacobus, of Stevens Institute, Hoboken, N. J., as its vice-president for the next meeting; and, on nomination to the general committee, he was duly elected.

To say the least, the program of Section D was very full. A large number of the papers were by the leading experts of the country on the subjects discussed. It is questionable whether the interests of science are the better advanced by permitting a more lengthy and general discussion of the papers presented, than by having the other sides of the same subject formally presented by some one who may not fully agree with the preceding author, but who has had time to prepare a written paper defending his position and advocating his opinions. While persons may differ in their opinions as to which is the better plan, the consensus of opinion of the members present was that the program presented gave them much information and food for thought. Many branches of mechanical science and engineering were touched upon, and while special emphasis was put upon those sessions devoted to aeronautics and hydrology, it was thought that the place and its surroundings warranted it.

The attendance at the meetings of the section has been excelled in recent years only by the 1902–3 Washington meeting. It is thought that this is encouraging for the future of the section. It is to be hoped that the members of the association connected with the section will show their continued interest in it by their attendance and by presenting papers at future meetings.

WM. T. MAGRUDER,
Secretary.

A REPLY TO RECENT STRICTURES ON AMERICAN BIOLOGISTS.*

A NOT uncommon, though possibly more or less indefinitely formulated, opinion has recently found an expression in print† to the effect that American systematic zoology has degenerated into a mere recording of minute facts, instead of being a study of problems; in other words, that it has been reduced to a somewhat low-level, though possibly sometimes useful, craft, and has lost caste among the sciences.

It must be admitted at the outset that this criticism is deserved to a limited extent. If we take ornithology as an example, what are the results of our labors in this country? Look over the long files of the *Auk* and see what they contain: An astounding and in many ways admirable record of facts relating to the distribution of our birds, their habits, their specific and subspecific characters! The refinement and acumen of discrimination with regard to the latter have reached a high degree of development, and it is doubtless true that the birds of North America are better known than those of any other part of the globe of even approximately similar extent. Our collections of native species are vastly larger and more complete than those of any other country and our methods and technique, both of collecting and of recording, greatly superior to those of the rest of the world. And the work goes on unceasingly, and the details are being more skilfully and accurately and voluminously elaborated every day. In fact, we are working so fast and so well that we have left the rest of the ornithological world far behind. Some of the younger European ornithologists are trying to catch up, but they will never be able to do so because the North American material can only be had here and because we have gained such a lead in the race.

But for what purpose are we accumulating all this minute detail, this enormous material? What are we straining our best faculties, our acknowledged ingeniousness, for? Thus far we have but little to show that would give a satisfying answer to these questions. On the surface, at least, it looks as if we were following these pursuits chiefly for their own sake, for the satisfaction of mere accumulating, for the exercise of these mental faculties. To the outsider it must certainly appear as if we regard the work we are doing as an end, not as a means towards an end. The ques-

* Read at the Twenty-first Congress of the American Ornithologists' Union, at its meeting in Philadelphia, November 18, 1903.

† Talcott Williams, 'On the Skirmish Line of Science,' *Booklover's Magazine*, II., November, 1903, p. 458.