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 4, 1908

CONTENTS

MSS. intended for publication and books, etc., intended for review should be sent to the Editor of SCIENCE, Garrison-on-Hudson, N. Y., or during the present summer to Wood's Hole, Mass.

THE TEACHING OF MATHEMATICS TO STUDENTS OF ENGINEERING[1]

WHAT IS NEEDED IN THE TEACHING OF MATHEMATICS TO STUDENTS OF ENGINEERING? (*a*) RANGE OF SUBJECTS; (*b*) EXTENT IN THE VARIOUS SUBJECTS; (*c*) METHODS OF PRESENTATION; (*d*) CHIEF AIMS.

By CALVIN M. WOODWARD, Professor of Mathematics and Applied Mechanics, and Dean of the School of Engineering and Architecture, Washington University.

I want to emphasize the point which Mr. Scott has just touched on, and that is that we often attempt too early to teach the subjects that require mature and reflecting minds. I want to tell you a story, a true biography of some one you all know of. He went through, in the city of New York, the whole range of mathematics, including analytic geometry and calculus. He learned his formulæ and definitions and "passed" in some manner, but, he told me, he did not know anything about them. He believed he was a dunce, and whenever he was required to make an intelligible demonstration, he could not do it; his teachers and his parents concluded that he was a dunce in mathematics, and could

[1] General discussion following the presentation of four formal papers (see SCIENCE, July 17, 24 and 31, 1908), and of the eight prepared discussions (see SCIENCE, August 7 and 28, 1908). Presented before Sections D and A of the American Association for the Advancement of Science and the Chicago Section of the American Mathematical Society, at the Chicago meeting, December 31, 1907.

never do anything in it. He would have gone through life with that notion, if some one had not offered him an appointment to West Point. He doubted his ability to pass the entrance examination in arithmetic; but his friends advised him to get an arithmetic and study. He bought a book and sat down and read the book through, and to his astonishment he found it easy. He passed his examination with flying colors. He entered West Point and graduated at the head of his class in mathematics, and is now at the head of a high grade technical school. If it had not been for the opportunity of going again over his whole course of mathematics, he would have gone to his grave thinking he had no capacity for mathematical analysis. That comes from poor or premature teaching.

I am opposed to putting college mathematics in high schools. Those young people may get a glimmer of it, but they get false impressions from it which are hard to remove. I have been teaching mathematics for forty years or more, and have been teaching applied mechanics for the same time. I taught Rankine for twenty-five years. It has always been my duty and my privilege to make my students see what mathematics was good for. And I want to defend the teachers of high school and freshman mathematics from what I think is unjust criticism. It is charged they do not make their students understand what mathematics is good for. It is simply impossible for them to do so, as I can do in mechanics. A man is very fortunate who can teach mathematics and then show what it is good for. I am old enough to quote a little of my early experience. I am led to it by something Professor Swain said in regard to mental processes. There is nothing so valuable to mathematical success as a clear grasp of fundamental principles. When I was preparing for college I gave all my time to Latin and Greek. I had done all my freshman mathematics and was reputed to be strong on that branch, when a new teacher came into the school who said, "Here's a new book in intellectual arithmetic, and I would like to have every student in the school go through it." It was fun for me, of course, but I went through the book from A to Z; no other mathematics that I ever studied did me so much good. The teacher's maxim was, "Take hold of the thread at the right end." That was the secret of his splendid teaching. I have applied that maxim to every branch of mathematics I have ever studied or taught. I have learned to take hold of mathematics at the right end, and in a measure I have taught my students to do so.

By B. F. Groat, Professor of Mechanics and Mathematics, School of Mines, University of Minnesota.

Most of the speakers have stated that what they were about to say had already been said by preceding speakers. I am going to try to state a general principle I have not heard clearly put since I came here. During the lunch hour Professor Slaught said that he had not heard a single general pedagogical principle brought out. I am going to take the honor to myself, to give expression to what seems to me to be a general educational principle.

Mathematics is mathematics and engineering is engineering. There is just as much art, science or principle in the teaching of mathematics as there is in the teaching of engineering and these two subjects should be distinguished, separated and kept separate. If you are going to teach engineering you must teach the pure principles. If you are going to teach mathematics you have got to teach pure mathe-

matics. Let it be pure or applied mathematics, it is the *principle involved* which must be taught. If this rule is not adhered to we shall find ourselves teaching something different from that which it was intended to teach.

The principle is that the technical courses in our engineering schools must be separated from our general educational courses. The technical courses are for the purpose of fitting the man for a special life work which is to come later on. The general education which he should have, by way of preparation, should precede his technical course as far as possible.

The straight technical course should be given as a course of two years extent, while the general and preparatory subjects should precede in a three- or four-year course.

The University of Minnesota has adopted a five-year engineering course. This is along the lines I am recommending and I prophesy that it will soon be extended to other schools and separated into two parts.

Let your professor of engineering teach engineering and your professor of mathematics teach mathematics. That is the general pedagogical principle I want to announce.

By C. S. HOWE, President, Case School of Applied Science.

I have been very much interested in the discussion of this subject because for thirteen years I was a professor of mathematics in an engineering school and during the past five years I have been endeavoring to reconcile the differences between professors of mathematics and professors of engineering. One thing in this discussion which strikes me as very peculiar is the sad lack of knowledge displayed by the engineering professors as to what is being done in mathematics in their own schools. I believe from my experience and from what I have seen in other institutions that the professors of mathematics are teaching mathematics most admirably as mathematics, but they are not teaching mathematics as a department of engineering. I do not believe that mathematics should be taught as a department of engineering. Mathematics is a science in itself and should be taught by specialists in that science if our students are to be trained in the proper way. The professor of mathematics has two duties to perform. One is to teach his students the principles of mathematics—that is, to teach them to reason and to understand why certain processes are right and why others are wrong. The student must also be taught how to use his mathematics so that he can solve any problem as soon as that problem is expressed in mathematical terms. Another duty of the mathematician is to teach the student to be exact. Unless the engineer is exact, unless he can obtain definite and reliable results in his engineering work, he can not succeed in his profession. This accuracy must be very largely taught in the mathematical department and much of the time and care bestowed upon classes is for the purpose of accomplishing this result.

I believe also that the professors of engineering are teaching engineering thoroughly and well. The difficulty which we are discussing to-day is not in the teaching of mathematics alone nor in the teaching of engineering alone, but in the connection between the two. The technical student is, I believe, taught pure mathematics well, but when he enters the class in engineering he finds that he has to deal with mathematics under a new form—that is, the particular engineering subject he is studying must be translated into mathematical terms and this is where he frequently meets with great difficulty. The student in algebra who has learned to solve equa-

tions of the first degree may have great difficulty with problems involving equations of the first degree because he has not learned to state the problems in mathematical language. So the student who begins electrical work finds certain problems containing known and unknown quantities, but not yet expressed in mathematical terms. Now I can not believe that it is the duty of the professor of mathematics to teach the student to express problems in the various branches of engineering in the form of equations or other mathematical terms. In order to do this it would be necessary for him to understand all the various branches of engineering and it is manifestly impossible for him to do this. The professor of civil engineering understands the problems of that subject and he should show the student in his department how to express these problems in such terms that the student can deal with them mathematically. The same may be said of each of the departments of engineering. When the professors of engineering have taught their students to state the problems of their own departments in mathematical language, then the student who has had the course in mathematics ought to be able to solve the problems, and if he can not he has not been taught his mathematics thoroughly or so much time has elapsed since he studied the subject that he has forgotten some parts of it.

Again, I believe that the professor of engineering should ascertain in a general way how mathematics is being taught in his institution and in just what form the student is using certain terms so that he may express his own problems in a way familiar to the student. If, for instance, in calculus the mathematical department has been using derivations, the professors of engineering in writing their problems should use differential coefficients and not attempt to express problems in terms of differentials. I know from experience that many professors of engineering do not do this and their students are confused by a difference of terms and not by a lack of knowledge of the subject. It is evident that the professors of engineering must conform to the methods of the department of mathematics because the department of mathematics can use but one method while the five or more departments of engineering might have several different methods. It is obvious, then, that for the sake of simplicity one method must be used and that method must be the method of the department of mathematics.

I also believe that the professor of mathematics should occasionally confer with the professors of engineering in order to find out from them just what mathematical subjects engineering students are weak in and what subjects it is especially desirable to have them well trained in and to see that his students are taught these things. Friendly conferences between the departments are of great value and should be encouraged by both the mathematicians and the engineers.

By Clarence A. Waldo, Professor of Mathematics, Purdue University.

In the table of hours for mathematics in the various institutions cited by Professor Townsend, the largest total stands against Purdue. Also a whole semester is assigned to trigonometry. Both of these conditions are in a measure due to the fact that we have recently passed through a transitional period in which for engineers solid geometry has been relegated to the secondary schools. The first semester was formerly divided between solid geometry and trigonometry. Now it is wholly given to the latter, while the second semester is set aside to college algebra. Experience shows that for the ordinary student college

algebra is more difficult than trigonometry and this determines their order in our program.

Placing trigonometry first and giving it so much time has developed with us several interesting facts.

1. Being easy to understand and having interesting applications, it naturally follows secondary work.

2. While trigonometry is easy to understand, yet to acquire facility in its use and absolute mastery over it as a fundamental science requires close and long-continued study, yet the student, ambitious to become an engineer, quickly sees that he must have facility in this subject and mastery over it.

As a subject of study, therefore, at the beginning of a young man's college career it is well adapted to give power and to instill habits of thoroughness, application, concentration and mastery.

3. Engineers have been recommending that a generous amount of time shall be given to trigonometry, at the expense of the calculus if necessary.

4. The subject is used to review and emphasize much of the preparatory mathematics, while it is also used to clear the way for that which is to come.

Another peculiarity in which Purdue stands almost alone we are quite prepared to defend. We do not crowd the pure mathematical work into the first two years, much less into the first year, but give it an hour less in the second year, than the first, yet at the outset of the third year, with his first course of calculus fairly mastered, we have the student well prepared to begin attack upon theoretical mechanics and kindred subjects. However, with two hours a week during junior year devoted to the further exploration of the calculus carried on side by side with its application to studies of a nature more or less professional, like thermodynamics, the student is likely to come finally into living contact with calculus ideas. Through three years, then, mathematical ideas are held persistently and prominently before the mind of the student, so that at the end of that time the mental change which I call the mathematical transformation is quite complete. If you are intent upon making a physical transformation by which a weak man becomes robust and powerful, you give one, two or three years for the muscles to grow and the chest to expand through long-continued and systematic exercise. Similarly the average student does not become habitually mathematical and exact in his thinking unless you give him careful direction and devote plenty of time to his development. The man who uses his memory and copies slavishly must disappear. In his place must stand the man of trained intellect, thoughtful, persistent, rich in expedients, powerful in attack. To produce him there are on the mathematical side two indispensable requisites, thoroughness in the fundamentals, and a sufficient time to make the mathematical attack of a problem habitual and natural, and to give such a control of and power in the use of the tools of mathematics that the solution of a problem of average difficulty shall be easy and pleasurable.

In the required mathematical part of the engineering courses at Purdue these are the considerations that determine the distribution of the work in the four-year program, and all of the time we are teaching not alone the particular subject that happens to be named in the curriculum—but mathematics.

Some years ago it was my fortune to study descriptive geometry under Marx and Von Derlin in Munich. They taught their subject from the standpoint of the mathematician rather than that of the draftsman. They made their students visualize geometric form in space and by

the use of that power discover methods of solving on paper synthetic problems of much difficulty. The German schools teach descriptive geometry as a mathematical subject, the American schools as a body of problems to be solved by rule on the drawing board. The former method makes descriptive geometry the finest discipline of the four years' course; from the other method little educational benefit arises. Some years ago at the Rose Polytechnic, where for a time we taught descriptive geometry in the German way, it was not unusual to meet students who declared enthusiastically that they got more real good from this subject than from anything else in their entire course.

I would ask the new committee to inquire how and by whom descriptive geometry should be taught?

By C. B. Williams, Professor of Mathematics, Kalamazoo College.

The teachers of mathematics in the small colleges of the middle west are preparing many men for work in the better technical schools. From our standpoint there is substantial agreement between the two representatives of the Massachusetts Institute of Technology (Professors Wood and Swain). They expressed themselves so differently that one might easily fail to see how closely they agree. Both want longer and stronger courses in mathematics in the secondary schools. I would like to know the college teacher of mathematics who does not agree with them. They want more mathematics taught and to have it taught better, to have longer and more consecutive mathematical courses in the secondary and primary schools. In other words, the faculties of the technical schools and colleges are working toward the same end, that is, to have more effective courses in primary and secondary mathematics so that college students can do more and better mathematical work. If we could have properly prepared students, we could turn out the kind of men the better technical schools should have.

The engineers and teachers of engineering have insisted that the most necessary qualification for a real engineer is that he should be able to realize his mathematics, to "think mathematically," as they express it. The mathematicians want the same thing. We are trying to make use of and to train the faculty of geometric intuition, to emphasize the functional notion and to develop functional thinking. There is substantial agreement that the best way to do this is through geometry, with perhaps some help from elementary mechanics. It is true that sometimes we are tempted to use too big and complicated machines for little problems, but this is only because we are attempting to develop methods powerful enough to solve big problems.

By J. B. Webb, Professor of Mathematics and Mechanics, Stevens Institute.

Every practical problem requiring mathematics for its solution consists of three parts:

(*a*) An *Analysis,* which resolves the problem into its elements, examines these in the light of natural laws, rejects unimportant ones and defines the relations existing between those upon which the solution depends. This involves the adoption or discovery of methods of measuring the elements, so that they may be expressed quantitatively by symbols, and of the reduction of the relations between them to the standard mathematical forms of expression. The result is a *mathematical statement of the problem* by one or more *equations.*

(*b*) A *solution* of the equations by which the relations sought for between the quantities are clearly expressed or the quanti-

ties put in proper form to have their values calculated.

(*c*) The *interpretation* of the result, which involves a translation of the same from the mathematical language in which it has been obtained into the original language of the problem and a discussion of the practical bearings of the same.

In conversation with a fellow mathematician at this meeting he surprised me by saying that he expected a problem to be put into mathematical language before it was submitted to him and I presume he did not feel bound to interpret his results. Now if "pure mathematicians" regard practical problems in this way, engineers and other practical men have just cause for finding fault with "pure mathematics," and to teach mathematics in this way is to render it valueless to most students. Personally I should refuse to undertake a problem unless I made the analysis and interpretation as well as the solution.

In many if not in most problems the analysis and interpretation are the main parts. They require a broad knowledge of practical conditions and of other sciences and are far more interesting than the mere solution, especially as they often bring into play a large amount of ingenuity and invention, as well as imagination and judgment. A mathematician who can not make the analysis and interpretation of a problem is not to be trusted with the solution and an engineer who is fully competent to make them had better undertake the solution himself or put the whole problem into the hands of a mathematician fully competent to undertake it.

There is no excuse for a "pure mathematician" remaining ignorant of the practical side of the problems he teaches, and his mathematics will not be interesting or trustworthy. Let him cultivate the acquaintance of the truly educated engineer, who will be only too glad to discuss problems with him and give him all the practical information he needs. But there are too many engineers who are not truly educated and who know less about mathematics than the "pure mathematician" does about practical things, and they ought to cultivate the acquaintance of the mathematician and rub off the worst parts of their ignorance before they attempt to criticize the teaching of mathematics. But it is much easier to find fault and say that they never found any use for such and such mathematical branches, when they never gave them enough attention to make them of any use.

Every mathematical teacher should teach all three parts of a problem, but the average engineering student is so indifferent to real progress and his limited time is so taken up with other things that he may get through his course knowing very little about mathematics, no matter how well it may be taught.

Students with fair ability that really want to learn a particular subject can do it even under indifferent teachers, but unless students exert themselves to learn, the best teacher can not put knowledge into them. Discuss the subject to the limit, analyze and adjust the engineering courses to a nicety, write new text-books, adopt new systems and get new teachers and the thing will remain about as it is; teachers will teach and students will expect them to, while only a few will learn, whether the teacher expects them to or not.

By H. T. EDDY, Dean of the Graduate School and Professor of Mathematics and Mechanics, College of Engineering, University of Minnesota.

Complaint has been made that in our teaching of mathematics we do not pay due attention to psychological and pedagogical principles. I want to consider for a mo-

ment the application of two of these principles.

First, it is necessary for the engineering student to have an ample undergraduate course in mathematics, and such an extended drill in and habitual acquaintance with its processes that when he has forgotten nine tenths of it, just as he will of this and all other subjects which he studies in college, what remains with him will be a sufficient equipment in this line for his professional career. In other subjects his residuum of knowledge is easily refreshed and increased. Not so in mathematics. The stock of mathematical knowledge of which he is easily master on entering his profession will practically be the end of his attainments in that direction. Restricting the course in mathematics to bare essentials is suicidal, for of it a small fraction only will remain as a permanent possession, and that fraction is likely to be smaller, the smaller the amount originally attempted.

Second, the teacher of mathematics is prone to think that a clear presentation of mathematical truth on his part, and a logical demonstration by the student, are all that is required in this subject. But important as these things assuredly are, they are insufficient to produce successful results. The question is one in which human interest is really of more importance than logic, for mathematical knowledge can not be successfully imparted unless genuine interest on the part of the student can be in some way aroused. It goes without saying, that the teacher must first of all have that interest himself or he ceases to be a fit teacher. How he will awaken interest in his pupil depends upon his own personality. Many do this by help of problems which elucidate and apply the principles. Just here lies the reason for the usual inability of professional engineers to teach mathematics. They have no interest in mathematics itself. It is the engineering problem alone that interests them. To this matter of interest, or the lack of it, may be traced the failure which is apt to attend the separation of classes into divisions according to scholarship, for in that case the divisions made up of poor students lose the impetus to be derived from the interest which the good students exhibit in their work in which all participate to some degree.

By S. M. Barton, Professor of Mathematics, University of the South.

While standing here in the heart of the modern, bustling city of Chicago, and listening to this discussion, my mind goes back to the ancient city of Tarentum and her distinguished governor, Archytas. Archytas, while an able mathematician, was too practical, as we learn, to suit the ideas of the Platonic School, who objected to his mechanical solutions of certain mathematical problems as interfering with pure reasoning. Now, while I take an immense interest in applied mathematics (what mathematician at this day would not?) yet I confess to a feeling of sympathy with Plato in his condemnation of Archytas. At any rate I wish to enter my protest against a possible tendency to degrade mathematical teaching to the memorizing of thumb-rules, and to urge the advantage of a strong backbone of pure mathematics in our engineering courses.

I read with interest a paper presented at the Ithaca meeting of the Society for the Promotion of Engineering Education, by Professor Arthur E. Haynes of the University of Minnesota, in justification of the use of the expression "engineering-mathematics." I must say I was at first somewhat shocked by the expression, for I had always believed that *mathematics is mathematics* take it when and where you will. While I would agree heartily with

much that Professor Haynes said, and I do not doubt that his courses are interesting and instructive, yet I question the wisdom of drawing any sharp distinction in the college curriculum between the mathematics given to the engineering student and to any other class of students.

I find myself differing absolutely from the gentleman from the Massachusetts Institute of Technology, who apparently sees no beauty, much less utility, in the higher branches of pure mathematics. How Professor Woods, who has, by the way, written such a sound text-book on mathematics, can live amicably in the same state, much less in the same college, as his engineer-colleague, I am at a loss to understand—perhaps they have an occasional fight. But, joking aside, there is a dangerous tendency to adopt rules (slide and mental) and short-cut, approximate solution to the utter exclusion of rigid proofs. Is it wise to make a mere machine of the young engineer, even if thereby he becomes rich faster or grows poor less slowly? I freely admit, however, that too much theory would be disastrous, and that there is great room for improvement in the teaching of mathematics. The student should be taught how to use his mathematics, and the existing gap between theory and practise be bridged. While affording every possible facility to the student for making experiments, collecting data, becoming expert in handling instruments, making calculations, etc., I urge that we give them, one and all, a good rigid course in *pure* mathematics.

By ARTHUR E. HAYNES, Professor of Engineering-Mathematics, University of Minnesota.

I have been called upon, by name, to defend the use of the term, "Engineering Mathematics." The justification of the term will be found in my paper on the subject in Volume XIV. of the Proceedings of the Society for the Promotion of Engineering Education. As the paper was not read before this association, many of the members present are not acquainted with its contents.

In brief, the reasons there given for the use of the term are:

(*a*) Because of the main object of the study of mathematics in engineering courses, viz: its use as a tool.

(*b*) Because of the proper method of teaching the mathematics of such courses.

(*c*) Because of the content of the mathematics of such courses.

It is not a degradation of mathematics to make it practical, it is rather an added glory. It is as justifiable to use this term as to use the corresponding terms agricultural chemistry, agricultural botany, engineering drawing, etc. We do not degrade chemistry or botany or drawing by the use of these terms: but their employment is justified by the objects of the study, by the methods required in teaching them and by their content, as in mathematics.

It has been suggested that a less thorough study of mathematics is advocated. In reply to this, may I quote from an article in Volume VIII. of the Proceedings of the Society for the Promotion of Engineering Education, on "The Teaching of Mathematics to Engineering Students," where in speaking of such teaching I said:

(*a*) It should be of such a character as to produce an enduring stimulating effect upon the mind of the student.

(*b*) It should give the student the power to properly interpret mathematical language, and to accurately and skillfully use it.

(*c*) To secure these results, the teaching must be based upon a proper order of studies and carried forward in a rational, intelligent manner.

By Arthur S. Hathaway, Professor of Mathematics, Rose Polytechnic Institute.

In a paper on "Pure Mathematics for Engineering Students," published in the *Bulletin* for March, 1901, I expressed opinions which coincide with those given here to-day. I then said that instruction in mathematics for engineering students should have two objects (1) to develop an engineering mind, and (2) to develop mathematics as an instrument of research for the engineer. I came to these conclusions at that time as a result of inquiries made of graduates of several institutions, who were in engineering practise, and of their employers. From the latter, I have had the statement that it is inadvisable to place a man in the higher positions in engineering who has not had a good mathematical training, especially, in the calculus, which, they assert, develops those modes of thought which are necessary to the engineer.

I wish to call your attention to the fact that the fifty-four hours of analytical dynamics credited to Rose Polytechnic Institute on this chart are spent on applied calculus. There is a regular course of one hundred and forty-four hours in Rankine not mentioned here, which is given by my colleague, Professor Gray. In applied calculus we take up problems which require the use of the calculus, such as motions in constant, elastic and central fields, the bending of beams, the twisting of shafts, problems in electricity, in chemistry, etc. We take problems gathered from all sources, text-books, magazines, engineering professors, and discuss them in the class-room, with special reference to the analysis and its mode of application.

By Edward V. Huntington, Assistant Professor of Mathematics, Harvard University.

I desire to call attention to the fact that besides the analogy of mathematics as a tool or instrument, there is also the perhaps more significant analogy of the mathematician as the discoverer of quantitative relations which already exist in the problems themselves. Logarithmic relations between varying quantities, for instance, are not dragged into the problem from some artificial tool-chest, but are already present in the problem, and are analyzed out of the problem much as the precious metal is analyzed out of the ingot by the metallurgist. The practical mathematician is simply a scientist specially trained to perceive the quantitative aspects of physical phenomena.

By Donald F. Campbell, Professor of Mathematics, Armour Institute of Technology.

We have had a number of good ideas set before us in the last two days—ideas which we ought to make an effort to crystallize. I think that the present time is the psychological moment to have a committee appointed to draw up a report on mathematics for colleges of engineering. This report perhaps might be in the nature of a symposium, but it would be especially valuable if it considered in detail the subjects which should be emphasized in a course in mathematics for engineering students. These, however, are merely suggestions. I would not hamper the committee in their deliberations by outlining any particular course which they should pursue. The only condition which I would impose is that the committee be representative enough that all of us can look towards their report with the utmost confidence.

I would move that the chairman be empowered to appoint a committee of three, these three to increase their number to fifteen, chosen from among the teachers of mathematics and engineering and the practising engineers, these fifteen to con-

stitute a committee authorized by this meeting to make such a report on mathematics for colleges of engineering as in their opinion will be of service to teachers in such institutions, and to submit this report when completed to the Chicago Section of the American Mathematical Society.

THE INTERNATIONAL GEOGRAPHICAL CONGRESS[1]

THE ninth International Geographical Congress, which began with a reception on Sunday, July 26, ended on August 6 with a banquet given by the Council of State of the Canton of Geneva. The congress has been marked by one unique feature—its unprecedented length. Hitherto a week has been the limit of the session of these congresses, and why the Geneva congress should have been protracted to the weary length of thirteen days it is difficult to surmise.

On the social side Geneva has hardly been surpassed by any city in which the congress had previously met. From the president of the republic downwards every one has vied in making the 750 members of the congress feel that they were welcome.

The membership was thoroughly representative, and the discussions in the sections, as well as the daily intercourse outside the sections, between geographers of all nationalities, are sure to lead to good results, to a clearer conception as to the field of geography, and as to the best methods of solving the many problems with which it has to deal. As usual, the educational side of the subject gave rise to much discussion, a good deal of it of little value from the practical point of view, but still not without its uses. Perhaps on the whole the discussions on glaciation in the section devoted to that subject were of wider bearing and of more scientific value than those in any other section; but they had as much to do with geology as geography, as, indeed, was the case with subjects brought before certain other sections. Geography has quite a wide enough field of its own, without having to burden itself and overweigh a congress with matters outside its sphere. Perhaps the lecture that attracted most attention and had the widest hearings was that of M. Ch. Lallemand on the "Respiration of the Earth." M. Lallemand gave a clear exposition of the researches of Professor Eckert, of Potsdam, which seem to show that there is a daily tide on the surface of the earth, of small dimensions may be, but absolutely real. Other lectures deserving special mention were those of Professor Oberhummer, of Vienna, on Leonardo da Vinci and his influence on the geography of his time, and on the great cities as individuals; of Dr. Filchner, on his masterly exploration in Eastern Tibet and the region between the Hoangho and Yang-tsze; and of M. Alexandre Monet, on the Scarab containing the record of the circumnavigation of Africa under King Necho, this last leading to a vigorous discussion. Dr. Otto Nordenskjöld's account of the results of his Antarctic expedition, though not altogether new, suggested several interesting problems. An unusual feature was the exhibition, with interesting explanations by Frau Wegener, of a remarkable collection of Chinese paintings collected by herself, and supplementary to some extent to her husband's account of his expedition in central China.

At the London congress in 1895 a committee was appointed at the suggestion of Professor Penck, now of Berlin, for the purpose of securing international action for the construction of a map of the world on the scale of 1 to 1,000,000, about sixteen miles to the inch. The scale has been adopted as a sort of standard scale, but otherwise little progress has been made. At Geneva those interested in the scheme decided to form a committee for the purpose of agreeing upon lines on which the proposed map should be constructed. After one or two meetings the committee came to definite conclusions, not only as to the scale, but also as to the symbols to be adopted to represent the various features on the map, the lettering to be used, the size of the sheets, the initial meridian (Greenwich), the use of the metric system (along with others if desired by individual states), and other points.

[1] Abridged from an article in the London *Times*.